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THE ROLE OF PEDIATRIC CARDIOLOGY IN THE MANAGEMENT OF CONGENITAL HEART DISEASE: A COMPREHENSIVE SYSTEMATIC REVIEW

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ABSTRACT

Background: *Congenital heart disease (CHD) represents the most common congenital anomaly, affecting approximately 1% of live births worldwide. This systematic review aims to evaluate current evidence on the role of pediatric cardiology in the management of congenital heart disease.*

Methods: *The study followed PRISMA 2020 guidelines, reviewing English-language publications from 2015 to 2025. Editorials, duplicate reviews from the same journal, and papers lacking a DOI were excluded. The literature search was conducted using PubMed, SagePub, SpringerLink, and Google Scholar.*

Result: *A total of 2,172 articles were initially identified through online databases (PubMed, SagePub, SpringerLink, and Google Scholar). After three rounds of screening, eight relevant studies were selected for full-text analysis.*

Conclusion: *Pediatric cardiology is essential in CHD management, ensuring early diagnosis, specialized interventions, and lifelong care. Advancements in technology and early detection enhance outcomes, while ongoing research and healthcare improvements remain crucial for optimizing survival rates and quality of life.*

Keyword: Congenital heart disease, pediatric cardiology, management

INTRODUCTION

Congenital heart disease (CHD) represents the most common congenital anomaly, affecting approximately 1% of live births worldwide. Advances in diagnostic techniques, surgical interventions, and medical management have significantly improved survival rates, leading to an increasing population of children and adults living with CHD. Pediatric cardiology plays a pivotal role in the continuum of care for these patients, encompassing early detection, risk stratification, medical optimization, interventional procedures, and long-term follow-up. However, variations in management strategies and outcomes necessitate a comprehensive review of the evolving role of pediatric cardiology in CHD care.[1,2]

Early detection of CHD has been revolutionized by fetal echocardiography, which allows for prenatal diagnosis and strategic perinatal planning. In some cases, fetal cardiac interventions have been introduced to improve in utero hemodynamics and postnatal outcomes for conditions such as critical aortic stenosis and hypoplastic left heart syndrome. Postnatally, advancements in transthoracic and transesophageal echocardiography, cardiac MRI, and CT angiography have further enhanced diagnostic accuracy, enabling precise anatomical and functional assessment of congenital cardiac lesions. Despite these advances, the impact of early detection on long-term clinical outcomes remains an area of active investigation.[3,4]

In addition to diagnostic improvements, interventional pediatric cardiology has significantly expanded treatment options for CHD. Catheter-based procedures, such as balloon valvuloplasty, atrial septostomy, and transcatheter closure of septal defects, have reduced the need for open-heart surgery in select cases. More recently, hybrid approaches combining surgical and interventional techniques have been introduced, offering less invasive alternatives for complex congenital heart lesions. However, the long-term safety and efficacy of these interventions compared to traditional surgical management require further evaluation.[5,6]

Surgical advancements have also played a crucial role in improving outcomes for children with CHD. Complex procedures such as the Norwood operation for hypoplastic left heart syndrome and the arterial switch operation for transposition of the great arteries have transformed the prognosis of previously fatal conditions. Nevertheless, surgical decision-making remains challenging, particularly in cases requiring staged palliation or re-intervention. The role of pediatric cardiologists in preoperative planning, intraoperative guidance, and postoperative monitoring is essential in optimizing patient outcomes.[7,8]

Long-term management of CHD extends beyond childhood, as increasing numbers of patients survive into adulthood with repaired or palliated heart defects. Lifelong surveillance is necessary due to the risk of late complications such as arrhythmias, heart failure, and pulmonary hypertension. Pediatric cardiologists are integral in the transition of care from pediatric to adult congenital heart disease (ACHD) specialists. However, disparities in access to specialized care and gaps in transitional care models pose significant challenges that warrant further investigation.[9,10]

This systematic review aims to evaluate current evidence on the role of pediatric cardiology in the management of congenital heart disease. Specifically, it will evaluate advancements in diagnosis, interventional and surgical management, long-term outcomes, and emerging challenges in the field. By providing a comprehensive analysis of existing literature, this review seeks to identify best practices, knowledge gaps, and future research directions to further optimize CHD care.

METHODS

PROTOCOL

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

CRITERIA FOR ELIGIBILITY

This systematic review aims to evaluate current evidence on the role of pediatric cardiology in the management of congenital heart disease based on literatures of the last decade. The review aimed to provide insights to improve patient treatment strategies, with an emphasis on the significance of key findings in the reviewed studies. Inclusion criteria for the study included: 1) Papers published in English, and 2) Papers published between 2014 and 2024. Exclusion criteria were: 1) Editorials, 2) Papers without a DOI, 3) Previously published review articles, and 4) Duplicate entries in journals.

SEARCH STRATEGY

The keywords used for this research are congenital heart disease, pediatric cardiology, management. The Boolean MeSH keywords inputted on databases for this research are: *("Congenital Heart Disease"[MeSH] OR "Congenital Heart Defects"[MeSH] OR "Heart Defects, Congenital"[MeSH] OR "Cardiac Malformations"[MeSH] OR "Congenital Cardiovascular Disorders"[MeSH]) AND ("Pediatric Cardiology"[MeSH] OR "Cardiology, Pediatric"[MeSH] OR "Congenital Cardiology"[MeSH] OR "Pediatric Cardiovascular Medicine"[MeSH] OR "Children's Heart Specialists") AND ("Disease Management"[MeSH] OR "Patient Care Management"[MeSH] OR "Therapeutics"[MeSH] OR "Treatment*

Outcome"[MeSH] OR "Interventional Therapy"[MeSH] OR "Cardiac Surgery"[MeSH] OR "Percutaneous Coronary Intervention"[MeSH] OR "Postoperative Care"[MeSH] OR "Follow-Up Studies"[MeSH] OR "Long-Term Care"[MeSH] OR "Transitional Care"[MeSH]).

DATA RETRIEVAL

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

QUALITY ASSESSMENT AND DATA SYNTHESIS

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met the inclusion criteria underwent further evaluation. Final decisions on inclusion were based on the findings from this review process.

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	("Congenital Heart Disease"[MeSH] OR "Congenital Heart Defects"[MeSH] OR "Heart Defects, Congenital"[MeSH] OR "Cardiac Malformations"[MeSH] OR "Congenital Cardiovascular Disorders"[MeSH]) AND ("Pediatric Cardiology"[MeSH] OR "Cardiology, Pediatric"[MeSH] OR "Congenital Cardiology"[MeSH] OR "Pediatric Cardiovascular Medicine"[MeSH] OR "Children's Heart Specialists") AND ("Disease Management"[MeSH] OR "Patient Care Management"[MeSH] OR "Therapeutics"[MeSH] OR "Treatment Outcome"[MeSH] OR "Interventional Therapy"[MeSH] OR "Cardiac Surgery"[MeSH] OR "Percutaneous Coronary Intervention"[MeSH] OR "Postoperative Care"[MeSH] OR "Follow-Up Studies"[MeSH] OR "Long-Term Care"[MeSH] OR "Transitional Care"[MeSH]).	466
SpringerLink	("Congenital Heart Disease"[MeSH] OR "Congenital Heart Defects"[MeSH]) AND ("Pediatric Cardiology"[MeSH]) AND ("Disease Management"[MeSH] OR "Patient Care Management"[MeSH] OR "Therapeutics"[MeSH])	402
Sagepub	("Congenital Heart Disease"[MeSH] OR "Congenital Heart Defects"[MeSH]) AND ("Pediatric Cardiology"[MeSH]) AND ("Disease Management"[MeSH] OR "Patient Care Management"[MeSH] OR "Therapeutics"[MeSH])	500
Google Scholar	("Congenital Heart Disease"[MeSH] OR "Congenital Heart Defects"[MeSH]) AND ("Pediatric Cardiology"[MeSH]) AND ("Disease Management"[MeSH] OR "Patient Care Management"[MeSH] OR "Therapeutics"[MeSH])	804

Table 2. JBI *Critical appraisal of Study*

Parameters	Bertaud (2016)	Rashid (2016)	Lantin-Hermoso (2017)	Rassaf (2020)	Baumgartner (2020)	Hinton (2017)	Triedman (2016)	Hernández-Madrid (2018)
1. Bias related to temporal precedence Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Bias related to selection and allocation Was there a control group?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Bias related to confounding factors Were participants included in any comparisons similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Bias related to administration of intervention/exposure Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No.	No.	No.	No.	No.	No.	No.	No.

5. Bias related to assessment, detection, and measurement of the outcome								
Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the outcomes of participants included in any comparisons measured in the same way?	No.	No.	No.	No.	No.	No.	No.	No.
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Bias related to participant retention								
Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Statistical conclusion validity								
Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

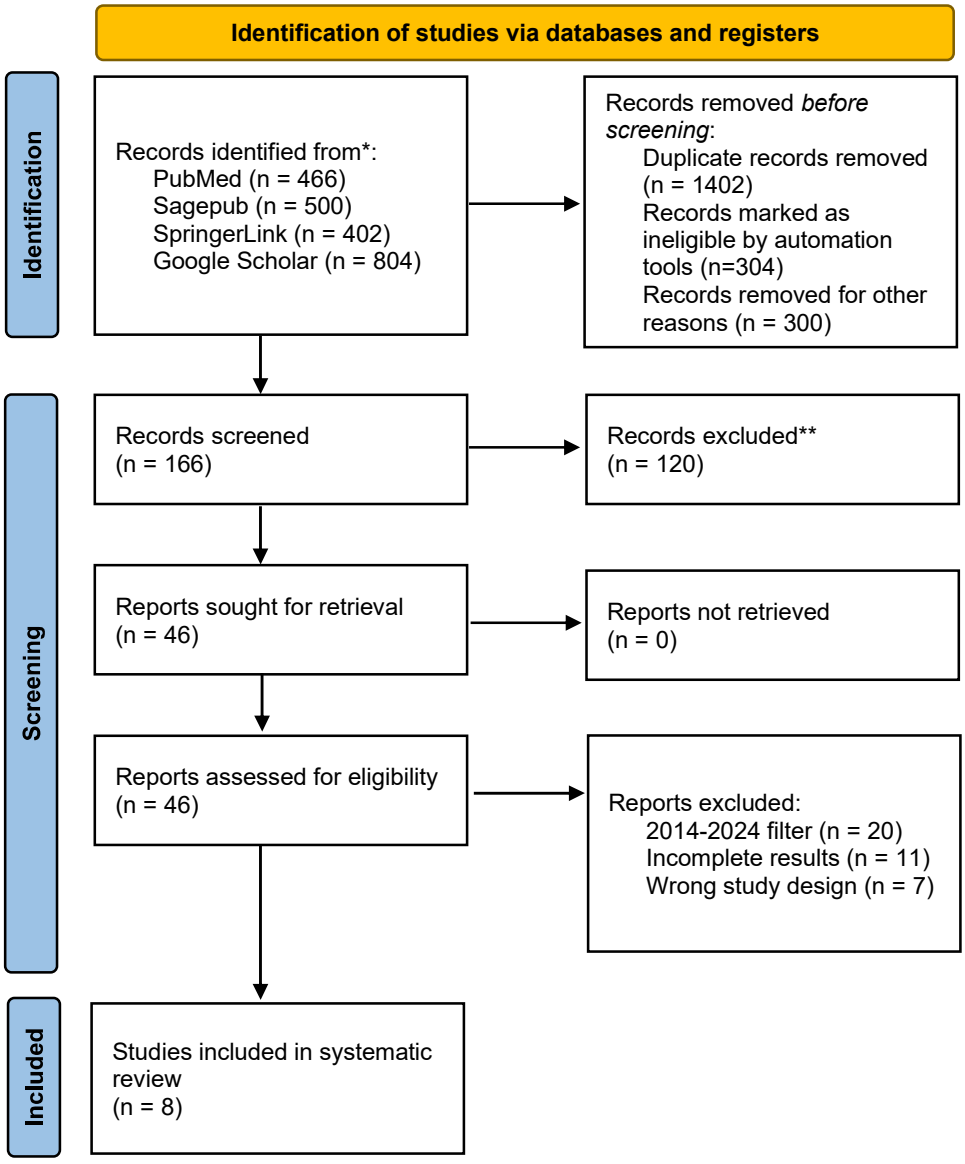

Figure 1. Article search flowchar

RESULT

The initial number of articles retrieved from online databases (PubMed, SagePub, SpringerLink, and Google Scholar) is 2,172 articles. After conducting three levels of screening, eight articles that directly relate to the current systematic review

have been chosen for further assessment through full-text reading and analysis. Table 1 presents the selected literature included in this analysis.

Table 1. The literature included in this study

No.	Author	Origin	Method	Sample	Result
1.	Bertaud, et al.[11] (2016)	UK	Retrospective study	-	Advances in CHD diagnosis and treatment have improved survival rates, allowing more children to reach adulthood. Early and consistent access to both specialist and non-specialist palliative care helps patients and families prepare for potential outcomes, improve symptom management, and make informed decisions. Understanding each patient's personal and moral context is essential for providing comprehensive, patient-centered care.
2.	Rashid, et al.[12] (2016)	Saudi Arabia	Retrospective study	354	In a study of 354 children with CHD (M:F ratio 1.7:1, median age 24 months), 85.1% experienced delayed diagnosis, primarily in acyanotic cases (65.3%), with a median delay of 8 months. Key contributing factors included delayed initial consultation (37.2%), misdiagnosis by healthcare professionals (22.5%), delayed referral (13.3%), social taboos (13.0%), and financial constraints (12.3%). Most children (88.7%) were born outside hospital settings. Those with fewer than two siblings (40%) had shorter diagnostic delays compared to those with two or more siblings (60%, $P < 0.001$). The findings highlight the need for better-trained healthcare providers, improved referral systems, and increased public awareness to facilitate early CHD diagnosis and management in developing countries.
3.	Lantin-Hermoso, et al.[13] (2017)	USA	Retrospective study	-	Pediatric cardiology plays a central role in the management of congenital heart disease (CHD) by coordinating care from diagnosis through long-term follow-up. Early detection, often through fetal echocardiography and neonatal screening, allows for timely intervention and improved outcomes. Pediatric cardiologists guide treatment strategies, including medical management, interventional catheterization, and surgical repair. They also play a crucial role in postoperative care, monitoring for complications such as arrhythmias, heart failure, and neurodevelopmental concerns. Beyond acute management, pediatric cardiology ensures continuity of care by facilitating transitions from hospital to home, coordinating with primary care providers, and preparing adolescent patients for adult congenital heart disease programs. Given the complex and lifelong nature of CHD, pediatric cardiologists are essential in optimizing patient outcomes, reducing morbidity, and improving quality of life.
4.	Rassaf, et al.[14] (2020)	Germany	Retrospective study	30	Pediatric cardiology plays a vital role in the comprehensive management of congenital heart disease (CHD) by providing specialized care across the patient's lifespan. From prenatal diagnosis through adulthood, pediatric cardiologists coordinate early detection using

					advanced imaging techniques, facilitate timely medical and surgical interventions, and ensure long-term follow-up to optimize patient outcomes. Their expertise in interventional cardiology enables minimally invasive procedures such as transcatheter valve repairs, septal defect closures, and hybrid procedures that reduce the need for open-heart surgery. Additionally, pediatric cardiologists work closely with multidisciplinary teams to address associated complications, including heart failure, arrhythmias, and pulmonary hypertension, while also supporting neurodevelopmental and psychosocial needs. They play a crucial role in guiding families through complex decision-making, managing transitions from pediatric to adult congenital heart disease care, and advocating for improved healthcare systems that enhance early detection and access to treatment. As survival rates for CHD patients continue to improve, pediatric cardiologists remain essential in advancing research, refining treatment protocols, and improving the quality of life for affected individuals.
5.	Baumgartner, et al.[15] (2020)	Germany	Retrospective study	-	The management of congenital heart disease (CHD) involves a multidisciplinary approach that includes medical, interventional, and surgical strategies tailored to the severity and type of defect. Early diagnosis through fetal echocardiography and neonatal screening is critical for timely intervention. Management strategies range from pharmacological treatment, such as diuretics and inotropes for heart failure, to interventional procedures like catheter-based closures for septal defects and balloon valvuloplasty for stenotic lesions. Surgical correction, including palliative and definitive repairs, is necessary for complex CHD cases such as tetralogy of Fallot and transposition of the great arteries. Postoperative care involves long-term follow-up to monitor complications such as arrhythmias, heart failure, and pulmonary hypertension. Lifelong surveillance with periodic imaging and functional assessment is essential, especially in adults with repaired CHD, as they remain at risk for late complications. Additionally, patient education and transition programs from pediatric to adult congenital cardiology centers are crucial in optimizing long-term outcomes.
6.	Hinton, et al.[16] (2017)	USA	Retrospective study	40	CHD management in pediatric patients involves a multidisciplinary approach aimed at addressing structural abnormalities, optimizing cardiac function, and preventing complications such as heart failure. Early diagnosis through fetal and neonatal screening is crucial for timely intervention. Management strategies include medical therapy for heart failure, catheter-based interventions such as balloon valvuloplasty and septal defect closure, and surgical correction for complex lesions like hypoplastic left heart syndrome. Postoperative care focuses on

					monitoring ventricular function, arrhythmias, and pulmonary hypertension while ensuring neurodevelopmental and psychosocial support. As many CHD patients survive into adulthood, long-term surveillance, transition to adult congenital heart disease programs, and personalized treatment approaches are essential for optimizing outcomes and quality of lif
7.	Triedman, et al.[17] (2016)	USA	Retrospective study	99	Early diagnosis through fetal and neonatal screening, along with improved intensive care strategies, has enhanced survival rates. Innovations such as prostaglandin therapy, balloon septostomy, and staged surgical procedures like the Norwood operation have improved outcomes for complex cases. Catheter-based interventions, including septal defect closures and valve replacements, have reduced the need for open-heart surgery. Additionally, advancements in cardiac imaging, electrophysiology, and mechanical circulatory support have further refined treatment strategies. With increasing survival into adulthood, there is a growing focus on long-term management, including addressing complications, ensuring seamless transition to adult congenital heart disease care, and integrating personalized treatment approaches. Future trends emphasize precision medicine, regenerative therapies, and improved global accessibility to CHD care.
8.	Hernández-Madrid, et al.[18] (2018)	Spain	Retrospective study	59	Pediatric cardiologists play a crucial role in identifying and managing arrhythmias associated with CHD, which may arise from congenital anomalies, surgical interventions, or post-operative complications. They utilize advanced imaging and electrophysiological techniques to assess cardiac function, detect conduction abnormalities, and guide interventions such as catheter ablation, pacemaker implantation, and pharmacological therapy. Additionally, pediatric cardiologists collaborate with multidisciplinary teams, including electrophysiologists and congenital heart surgeons, to optimize patient outcomes. With advancements in technology, including 3D mapping systems and improved ablation strategies, the management of arrhythmias in CHD patients has significantly evolved. Given the increasing survival rates of CHD patients into adulthood, pediatric cardiologists also play a key role in the transition to adult congenital heart disease care, ensuring continuity in monitoring and treatment

DISCUSSION

The role of pediatric cardiology in the management of congenital heart disease (CHD) is pivotal in ensuring early diagnosis, timely intervention, and comprehensive long-term care. Advances in CHD treatment have significantly improved survival rates, allowing more children to reach adulthood with manageable conditions.[11] Early and consistent access to both specialist and non-specialist palliative care services enhances symptom management, decision-making, and overall quality of life for both patients and their families. Understanding each patient's personal and moral context is essential for providing patient-centered care that aligns with their values and medical needs.[19]

Despite advancements in CHD management, delayed diagnosis remains a significant challenge, particularly in resource-limited settings. Rashid et al. (2016) found that 85.1% of children with CHD experienced delayed diagnosis, with a median delay of 8 months. The primary causes of these delays included late initial consultations, misdiagnosis by healthcare professionals, delayed referrals, and socioeconomic barriers such as financial constraints and social taboos. These findings underscore the need for improved training of healthcare providers, better referral systems, and increased public awareness to facilitate early CHD diagnosis and management, especially in developing countries.[12]

Pediatric cardiologists play a central role in coordinating care from the point of diagnosis through long-term follow-up. Early detection using fetal echocardiography and neonatal screening allows for timely intervention, which can significantly improve patient outcomes. Pediatric cardiologists guide treatment strategies, including pharmacological management, interventional catheterization, and surgical repair. Additionally, they oversee postoperative care, monitoring for complications such as arrhythmias, heart failure, and neurodevelopmental concerns. Their role extends beyond acute management, ensuring smooth transitions from hospital to home and preparing adolescent patients for adult congenital heart disease programs.[13]

Interventional cardiology has revolutionized CHD management by offering less invasive procedures that reduce the need for open-heart surgery. Rassaf et al. (2020) highlighted the importance of transcatheter interventions, such as valve repairs and septal defect closures, which minimize surgical risks and enhance recovery. Pediatric cardiologists collaborate closely with multidisciplinary teams to address associated complications, including heart failure, pulmonary hypertension, and arrhythmias. Their expertise in guiding families through complex decision-making and advocating for improved healthcare access has been instrumental in optimizing CHD outcomes.[14]

A multidisciplinary approach remains the cornerstone of CHD management, involving medical, interventional, and surgical strategies tailored to individual patient needs. Baumgartner et al. (2020) emphasized that early diagnosis through fetal echocardiography and neonatal screening is critical for timely intervention. Management strategies range from pharmacological treatments, such as diuretics and inotropes for heart failure, to interventional catheter-based procedures like balloon valvuloplasty. Surgical correction, including palliative and definitive repairs, is necessary for complex cases such as tetralogy of Fallot and transposition of the great arteries. Lifelong surveillance and patient education programs are essential for optimizing long-term outcomes.[15]

The evolution of CHD management has also been marked by advancements in pediatric heart failure treatment. Hinton et al. (2017) highlighted the importance of addressing structural abnormalities, optimizing cardiac function, and preventing complications through a combination of medical therapy, catheter-based interventions, and surgical correction. Postoperative care focuses on ventricular function monitoring, arrhythmia management, and pulmonary hypertension control while ensuring neurodevelopmental and psychosocial support. As survival rates improve, the emphasis has shifted toward long-term care strategies and transition programs to adult congenital heart disease centers.[16]

Innovations in CHD management, including prostaglandin therapy, balloon septostomy, and staged surgical procedures like the Norwood operation, have significantly enhanced survival rates. Catheter-based interventions, including septal defect closures and valve replacements, have reduced the need for open-heart surgery. Additionally, advancements in cardiac imaging, electrophysiology, and mechanical circulatory support have further refined treatment strategies. The growing focus on long-term management highlights the importance of addressing complications, ensuring seamless transitions to adult congenital heart disease care, and integrating personalized treatment approaches.[17]

Arrhythmias are a common complication in CHD patients, requiring specialized management by pediatric cardiologists. Hernández-Madrid et al. (2018) emphasized their role in identifying and treating arrhythmias that may arise due to congenital anomalies, surgical interventions, or post-operative complications. Utilizing advanced imaging and electrophysiological techniques, pediatric cardiologists assess cardiac function, detect conduction abnormalities, and guide interventions such as catheter ablation, pacemaker implantation, and pharmacological therapy. As technology advances, management strategies have evolved with the introduction of 3D mapping systems and improved ablation techniques, enhancing patient outcomes.[18]

Given the increasing survival rates of CHD patients into adulthood, pediatric cardiologists also play a key role in ensuring continuity of care. The transition from pediatric to adult congenital heart disease programs is crucial for maintaining long-term cardiac health and preventing late complications. Coordination between pediatric and adult congenital cardiology specialists allows for personalized treatment approaches tailored to each patient's evolving needs. Addressing gaps in transitional care and improving accessibility to specialized services remain key priorities in optimizing lifelong CHD management.[20–22]

CONCLUSION

Pediatric cardiology is essential in CHD management, ensuring early diagnosis, specialized interventions, and lifelong care.

Advancements in technology and early detection enhance outcomes, while ongoing research and healthcare improvements remain crucial for optimizing survival rates and quality of life.

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