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# Surgical Interventions in Children with Congenital Heart Disease: A Review Article

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**ABSTRACT:** Congenital malformation of the heart stands as one of the most common congenital anomalies at birth. However, with the advancement in cardiovascular medicine and surgery, a majority of the children can nowadays still live for about 20 years. Unfortunately, the prolonged survival has its own consequences and many children face late complications among which heart failure and arrhythmias are predominant. The burden of congenital heart pathology looms large on the pediatric population mortality and morbidity statistics. While a number of endovascular procedures have been conceived as a substitute for surgical correction, percutaneous interventions have shown positive outcomes in many cases — all this without the stress and trauma associated with surgery especially for frail children. Our aim was to provide a review to look into possibility and effectiveness of endovascular procedures plus Internal prosthetics for managing pediatric patients with congenital malformation of the heart.

## 1. INTRODUCTION

Congenital malformation of the heart stands as the most prevalent congenital ailment among infants. However, developments in cardiovascular medicine and surgery have paved the way for a majority of these children to live until adulthood. Yet, this prolonged survival has come at a grim cost— many succumb to late consequences with arrhythmias and heart failure reigning as kings among the adversities faced. It casts a dark shadow on pediatric population morbidity and mortality, with congenital heart pathology bearing a significant burden. However, all is not bleak on the horizon of these young children. There exists an alternative to these invasive surgical procedures— endovascular procedures along with Internal prosthetics. A ray of hope for those engulfed in frailty where surgical treatments would only add more trauma than relief. (Hoffman & Kaplan, 2002).

A minimally invasive procedure like percutaneous device treatment marked a dawn for children born with congenital heart anomalies. This included cases ranging from simple isolated defects such as pulmonary valve stenosis or patent ductus arteriosus (PDA) to more complex diseases like tetralogy of Fallot (ToF)and hypoplastic left heart syndrome (HLHS). The term percutaneous device therapy stands for using approved devices through catheters to manage these structural birth defects. A study probed failures post closure of ventricular septal defect (VSD)— finding 7.6% cases ended up failing the device used in this manner without any identifiable causative factor. No relation surfaced between weak evolution and child age, type of VSD or even characteristics of the device including its size or type. Others have also reported successful closures done percutaneously on aortopulmonary windows as well as anomalies between pulmonary arteries and veins along with fistulas... and not forgetting ruptured Valsalva sinus aneurysms (Moisa et al., 2022).

The use of Occlusion devicess for VSD closure has been successful since the end of the last century, demonstrating a less risky alternative to surgical interventions. PDA interventional closure was found effective with most cases not experiencing any complications; a study previously reported of the 407 children, only five cases reported complications post-procedure; notably, a large atrial defect size is indicative of positive future outcomes. Balloon atrial septostomy's safety and efficacy have been demonstrated in transposition of great arteries that could also assist in both types of atrioventricular valve atresia and total anomalous pulmonary venous return— where no or only restrictive foramen ovale is present. Similarly, interventional procedures have found success during multistep palliation HLHS or even full correction certain variants ToF: more details needed on these cases are required for further analysis (Moszura et al., 2014).

Pediatric transcatheter innovation: there exist significant obstacles. Among them, the most prevalent barrier is an apprehension surrounding testing and validation of new devices in children— this supersedes a concern on ethical or legal fronts. Conflicting

knowledge hampering suggestions for developing and manufacturing children tools can impede further growth towards percutaneous treatment evolution. Yet despite all these difficulties and barriers, technological advancements have led to the emergence of novel pediatric devices (Moisa et al., 2022).

Our goal was to delve into research and assess the practicality and effectiveness of endovascular procedures as well as state-of-the-art Internal prosthetics for addressing congenital heart diseases in children. As a result, we present a fresh narrative review that encapsulates the fusion of diverse percutaneous treatment methodologies along with the technological apparatus used in pediatric interventional cardiology.

## SURGICAL INTERVENTIONS IN CHILDREN CARDIOLOGY

### 1. Critical Pulmonary Valve Stenosis/Atresia

This article speaks of somewhat scarce CHD but one which results in an increased mortality risk for children, even after surgical intervention with a 52% death rate in the first year: pulmonary valve atresia with intact ventricular septum. In order to improve clinical outcomes, various percutaneous techniques have been developed that include ductus arteriosus endoprosthesis and balloon valvulotomy as well as systemic-to-pulmonary shunt creation— the latter two being palliative interventions, ensuring only univentricular circulation (Vall Camell et al., 2019).

The majority of literature studies unveiled common procedures for balloon valvulotomy and pulmonary valve perforation. In one particular study, right coronary catheter was directed into the infundibular region. Various guidewires were then employed to achieve the perforation of an atretic pulmonary valve— including using the stiff end of a 0.014-inch guidewire or even 0.018-inch and 0.024-inch radiofrequency guidewires. An interesting approach taken post-perforation involved placing a 0.014-inch guidewire in the femoral artery; this allowed dilation of the pulmonary valve using balloons of escalating sizes. Some practitioners opted for balloons that were 20% bigger than the pulmonary annulus, but other practitioners went as far as using balloons with diameters up to 1.2–1.4 times larger. For children referred for ductal endoprosthesis as palliation, it is typically femoral access that is required— thus completing this series of interventions for such cases where it may be deemed necessary (van Hoek et al., 2011).

### 2. PERCUTANEOUS CLOSURE OF THE PATENT DUCTUS ARTERIOSUS

Children identified with PDA and possessing anatomical features that favor an interventional approach can thus be suggested for percutaneous closure within the infant's first year of life. The initial occlusion devices were not suitable for low body weight children; however, the Amplatzer Piccolo Occluder could be used even in children weighing 700g or more, approved by FDA before five years. A significant PDA was considered a contraindication due to high risk of protrusion into the aorta and pulmonary artery when using first-generation Occlusion devices, but notwithstanding this fact, one study found successful closure of large PDAs (with narrowest diameter 0.40 ± 0.10 cm) using Occlusion device II devices in children < 3 years old— considering that some kids are older than others based on their years but still within the specified age limit (Kumar et al., 2013).

The closure of PDA with an Occlusion devices is typically considered through the usual scenario where ductus arteriosus is crossed from the venous side towards the aorta. Majority of studies found that size of the device should be 1.0–2.0 mm larger than the narrowest diameter of ductus arteriosus which, when confirmed to be well positioned, has its distal disc opened and placed on ductal aortic side before delivery of occluder device is done. Nit-Occlud is a nitinol coil approved for percutaneous closure for PDAs < 3.9 mm in diameter for children > 4.9 kg aged ≥ 5.9 months, delivered using a 4F or 5F catheter also inserted from pulmonary side of PDA (Kobayashi et al., 2019).

### 3. PERCUTANEOUS INTERVENTION FOR AORTIC COARCTATION

The use of percutaneous balloon angioplasty with endoprosthesis or without endoprosthesis is considered in infants as well, where the need for surgical intervention can be avoided. Balloon angioplasty is typically preferred for young children with decreased body weight (less than 20.0 kg) due to the requirement of a bigger sheath size for endoprosthesis delivery. While a previously published article reported positive long-term outcomes for low-weight children undergoing aortic coarctation endoprosthesis, it also noted an increased risk of femoral artery occlusion; conversely, balloon angioplasty demonstrated effectiveness particularly in infants aged three to twelve months with low adverse event rates even when used acutely. Endoprosthesis implantation was found to be safe regardless of age (more than one year) or body weight (less than 30 kg vs. equal or more than 30 kg), although there are specific types of endoprosthesis that allow more expansion as the child grows: Intra-Endoprosthesis LD Max TM could reach 24–26 mm post-dilation versus Genesis endoprosthesis at 18.0–20.0 mm after expansion (Golden & Hellenbrand, et al., 2007).

In children selected for percutaneous intervention, both arterial and venous femoral input must be taken. Prior to angioplasty, Measurements need to be taken of the proximal and distal diameters of the aorta as well as stenosis length and coarctation length between the branches of the aortic arch. Balloon and endoprosthesis sizing should be based on the proximal aortic diameter since it can act as post-stenotic dilation; ease in passing through stenotic area can be achieved by placing Amplatz Super-Stiff wire distally in subclavian artery or snaring it through brachial approach (Wang et al., 2020).

A usual practice during percutaneous angioplasty is to use a balloon that is 0.1–0.2 cm bigger in diameter than the pre-stenotic aorta. Some researchers suggest testing stenosis distensibility before deploying the endoprosthesis by using low pressure (less than 4 atm) to inflate the balloon— as the endoprosthesis may not fully dilate in highly fibrotic stenosis after the first attempt. Upon growing, additional balloon inflations can be carried out to further dilating the endoprosthesis; although there are complications, instant cure ratio is excellent (96.9% even among low weight children). In one study performed in 2021 involving patients under 20 kg weight, the percentage of complications associated to femoral artery injury was 18%, with interventional procedure being most frequent (Boe et al., 2021).

## 4.CORONARY ARTERY FISTULA

The genesis of congenital coronary artery fistula (CAF) is a scarce occurrence among populations, with only 0.002% reported incidence rate. However, apart from the congenital origin, CAF can be a byproduct following surgical and interventional processes—examples include heart transplants or septal myomectomies. Even though some cases in the literature have shown spontaneous closure after time (specifically 28.9% after 21 months), more than half of CAF tend to enlarge over time. Moreover, CAF leads to various consequences and symptoms because of left-to-right or left-to-left shunts such as ischemia and endocarditis, among others—closing these types of fistulas might become necessary in selected children that present with symptoms of heart failure (Feltes et al., 2011).

CAFs have different emergence sites, with the right coronary artery being the most frequent. However, they can also arise from the circumflex coronary arteries, left main or left anterior descending, as noted in one particular study. The drainage pathways of CAFs typically depend on the anatomical and technical features to determine if percutaneous closure is feasible. A few observations based on an interventional approach would be: consider such an approach in children who have a one CAF diameter more than 0.2 cm and a straight pathway with slow drainage (Wu et al., 2021).

There are various techniques for CAF closure that have been identified. They point out the anatomical differences (drainage, pathway, origin). The antegrade venous approach (used for long CAF), retrograde arterial approach (effective for small and medium-sized CAF), arterio-arterial circuit approach (suitable when CAF drains in the left atrium or ventricle), and arterio-venous circuit approach (useful if CAF drains in the right atrium or ventricle). Various devices can be used based on CAF size, length, and drainage for percutaneous occlusion. These include Coils, vascular plugs, muscular ventricular septal occluder, and duct occlude, among others reported in one study. Some authors have pointed out successful use of the Occlusion device in percutaneous occlusion for larger CAFs with positive outcomes in both the short and long term: small residual shunts could potentially close by themselves few months later after the index procedure (Behera et al., 2006).

## 5. VENTRICULAR SEPTAL DEFECT

Congenital heart disease is the most frequently identified type of a child born with isolated ventricular septal defect (VSD), accounting for 2–5% of all cases. However, despite the high incidence rate, most small VSDs (almost 90%) close on their own within one year. The percutaneous correction is an option for children with significant hemodynamically VSD, which includes pulmonary to systemic flow ratio more than 2 or left heart volume overload; however, there was a study that considered pulmonary to systemic flow ratio $\geq 1.5$ as an eligibility criterion. According to the scientific statement made by American Heart Association (AHA), percutaneous closure is not preferable the closing of VSD in children who do not have adequate anatomy for device implantation and those who are asymptomatic without pulmonary hypertension — yet such asymptomatic cases may also have such presentations like this (Aal et al., 2021).

Successful occlusion of the ventricular septal defect in children selected for this minimally invasive procedure contributed at 6 months to the reduction in dimensions, volumes and mass of the left ventricle ($p < 0.05$ for all), without significant complications. One group described a large VSD for being too large a defect that could not be closed percutaneously as using a device and sheath larger than recommended based on body weight. The VSD diameters should be measured appropriately as they determine size selection; also, distance from valves guides choice of devices used during percutaneous closure among muscular or perimembranous VSDs with specific lengths (Moisa et al., 2022).

## 6. ATRIAL SEPTAL DEFECTS

Another birth disorder that is common is atrial septal defect, which affects one person in a thousand live births. Nowadays, The transcatheter closure of ASD has been taking over the role of surgery in numerous centres because of the accessibility and approval of occlusion devices in secundum ASD; thus, pediatric hemodynamically significant ASD is included in a class I indication according to AHA guidelines. Furthermore, the symptomatic children with transitory right to left shunt should consider transcatheter ASD treatment. However, percutaneous closure is not suitable for any other type of ASD than ostium secundum or those who have an advanced pulmonary vascular disease (Feltes et al., 2011).

The consistency of transcatheter ASD occlusion using double-disk devices is observed among various experimental researches. The procedure involves obtaining a femoral venous access site and then advancing a multipurpose catheter through the

ASD into the left upper pulmonary artery with the help of a guidewire. While determining the diameter of the defect, which should be added to that resulted from transesophageal echocardiography, use of a sizing balloon is recommended. The technique involves sizing based on balloon inflation until trans-septal flow stops, visualized echocardiographically— not to overestimate defect diameter; after measuring balloon diameter, appropriate device size is chosen. (Hijazi, 2011).

**7. GERBODE VENTRICULO-ATRIAL DEFECT**

The connection of the left ventricle and right atrium is described by a Gerbode defect. This defect can either be present at birth (as a scarce form of VSD) or acquired later in life (through cardiac surgery or other procedures like endocarditis). In the past, surgical intervention was the only option for treating Gerbode defects. However, with the development of various percutaneous occluding devices through transcatheter treatment as an alternative to open heart surgery, there is now another option— despite limited data from only case series and report (Haponiuk et al., 2021).

Among the most common methods used by authors to close Gerbode defects in children are catheters and guidewires. However, regardless of the specific tools used, the procedure demands arterial femoral access. To get through the defect from the left ventricle to the right atrium, a catheter is then pushed backward; then, a guide wire is coiled around and pulled out using an approach through the femoral vein. This creates an arterio-venous loop, through which an occluding device can be passed after successful confirmation of its position. In one particular study involving eight children with both congenital and acquired Gerbode defects, percutaneous closure using a Nit-Occlud Lê VSD coil was shown to be effective despite small residual shunts observed post-procedure. These were occluded in nearly all children later during follow-up— except for one who had a minor persiendoprosthesis defect without developing cardiac conduction disorders (a crucial consequences seen typically after surgical intervention) (Weryński et al., 2021).

**CONCLUSIONS**

The burden of congenital heart pathology looms large on the pediatric population mortality and morbidity statistics. While many endovascular procedures have been recommended as another intervention to surgical repair, percutaneous interventions have shown positive outcomes in many cases — all this without the stress and trauma associated with surgery especially for frail children. Our aim was to provide a review to look into possibility and effectiveness of endovascular procedures plus Internal prosthetics for managing congenital heart disease in children.

**REFERENCES**

1) Aal, A. A., Hassan, H. M., Ezzeldin, D., & El Sayed, M. (2021). Impact of percutaneous ventricular septal defect closure on left ventricular remodeling and function. The Egyptian heart journal : (EHJ) : official bulletin of the Egyptian Society of Cardiology, 73(1), 86. https://doi.org/10.1186/s43044-021-00215-z
2) Behera, S. K., Danon, S., Levi, D. S., & Moore, J. W. (2006). Transcatheter closure of coronary artery fistulae using the Occlusion device. Catheterization and cardiovascular interventions : official journal of the Society for Cardiac Angiography & Interventions, 68(2), 242–248. https://doi.org/10.1002/ccd.20811
3) Boe, B. A., Armstrong, A. K., Janse, S. A., Loccoh, E. C., Stockmaster, K., Holzer, R. J., Cheatham, S. L., Cheatham, J. P., & Berman, D. P. (2021). Percutaneous Implantation of Adult Sized Endoprosthesis for Coarctation of the Aorta in Children ≤20 kg: A 12-Year Experience. Circulation. Cardiovascular interventions, 14(2), e009399. https://doi.org/10.1161/CIRCINTERVENTIONS.120.009399
4) Butera, G., Carminati, M., Chessa, M., Piazza, L., Abella, R., Negura, D. G., Giamberti, A., Claudio, B., Micheletti, A., Tammam, Y., & Frigiola, A. (2006). Percutaneous closure of ventricular septal defects in children aged <12: early and mid-term results. European heart journal, 27(23), 2889–2895. https://doi.org/10.1093/eurheartj/ehl340
5) Feltes, T. F., Bacha, E., Beekman, R. H., 3rd, Cheatham, J. P., Feinstein, J. A., Gomes, A. S., Hijazi, Z. M., Ing, F. F., de Moor, M., Morrow, W. R., Mullins, C. E., Taubert, K. A., Zahn, E. M., American Heart Association Congenital Cardiac Defects Committee of the Council on Cardiovascular Disease in the Young, Council on Clinical Cardiology, Council on Cardiovascular Radiology and Intervention, & American Heart Association (2011). Indications for cardiac catheterization and intervention in pediatric cardiac disease: a scientific statement from the American Heart Association. Circulation, 123(22), 2607–2652. https://doi.org/10.1161/CIR.0b013e31821b1f10
6) Golden, A. B., & Hellenbrand, W. E. (2007). Coarctation of the aorta: endoprosthesis in children and adults. Catheterization and cardiovascular interventions : official journal of the Society for Cardiac Angiography & Interventions, 69(2), 289–299. https://doi.org/10.1002/ccd.21009
7) Haponiuk I., Chojnicki M., Gierat-Haponiuk K. (2021) Commentary on the Oryginal Article “Transcatheter Closure of Congenital and Acquired Gerbode Defects with Nit-Occlud Lê Vsd (Pfm) Coil. Immediate and Mid-Term Results” by Piotr Weryński Et Al. Folia Cardiol.;16:377–378. doi: 10.5603/FC.2021.0055.

8) Hijazi Z. M. (2011). Device closure of secundum atrial septal defects: To balloon size or not to balloon size. Annals of pediatric cardiology, 4(1), 34–35.
9) Hoffman, J. I., & Kaplan, S. (2002). The incidence of congenital heart disease. Journal of the American College of Cardiology, 39(12), 1890–1900. https://doi.org/10.1016/s0735-1097(02)01886-7
10) Kobayashi, D., Salem, M. M., Forbes, T. J., Gordon, B. M., Soriano, B. D., Dimas, V., Goldstein, B. H., Owada, C., Javois, A., Bass, J., Jones, T. K., Berman, D. P., Gillespie, M. J., Moore, J. W., & Levi, D. S. (2019). Results of the combined U.S. multicenter postapproval study of the Nit-Occlud PDA device for percutaneous closure of patent ductus arteriosus. Catheterization and cardiovascular interventions : official journal of the Society for Cardiac Angiography & Interventions, 93(4), 645–651. https://doi.org/10.1002/ccd.27995
11) Kumar, S. M., Subramanian, V., Bijulal, S., Krishnamoorthy, K. M., Sivasankaran, S., & Tharakan, J. A. (2013). Percutaneous closure of a moderate to large tubular or elongated patent ductus arteriosus in children younger than 3 years: is the ADO II appropriate?. Pediatric cardiology, 34(7), 1661–1667. https://doi.org/10.1007/s00246-013-0700-x
12) Moisa, S. M., Burlacu, A., Brinza, C., Țarcă, E., Butnariu, L. I., & Trandafir, L. M. (2022). An Up-to-Date Narrative Review on Congenital Heart Disease Percutaneous Treatment in Children Using Contemporary Devices. Diagnostics (Basel, Switzerland), 12(5), 1189. https://doi.org/10.3390/diagnostics12051189
13) Moszura, T., Góreczny, S., & Dryżek, P. (2014). Hypoplastic left heart syndrome - a review of supportive percutaneous treatment. Postepy w kardiologii interwencyjnej = Advances in interventional cardiology, 10(3), 201–208. https://doi.org/10.5114/pwki.2014.45148
14) Vall Camell, M., Rodríguez-Fanjul, J., Bautista Rodríguez, C., Pradda, F. H., Caffarena-Calvar, J. M., Iriondo Sanz, M., & Sánchez-de-Toledo, J. (2019). Manejo percutáneo de la atresia pulmonar con tabique interventricular íntegro y la estenosis pulmonar crítica [Percutaneous management of pulmonary atresia with intact ventricular septum and critical pulmonary stenosis]. Anales de pediatria, 91(5), 336–343. https://doi.org/10.1016/j.anpedi.2018.10.020
15) Wang, X., Pang, C., Liu, X., Wang, S., Zhang, Z., Chen, J., Zhuang, J., & Zhou, C. (2020). Congenital coronary artery fistula in children: transcatheter versus surgical closure. BMC cardiovascular disorders, 20(1), 484. https://doi.org/10.1186/s12872-020-01769-7
16) Weryński P., Kardiologii D., Polsko-Amerykański P., Wydział L., Robert S., Paweł S., Agnieszka W., Rudziński A. (2021) Transcatheter Closure of Congenital and Acquired Gerbode Defects with Nit-Occlud Lê Vsd (Pfm)-Coil. Immediate and Mid-Term Results Wyniki Przezskórnego Zamknięcia Ubytku Typu Gerbode Z Zastosowaniem Nit-Occlud Lê Vsd (Pfm)-Coil. Folia Cardiol.;16:369–376. doi: 10.5603/FC.2021.0054
17) Wu, Y. H., Li, T. Y., Lin, Y. J., Fang, C. Y., Huang, C. F., Fang, H. Y., Lo, M. H., & Lin, I. C. (2021). Mid-Term Follow-Up of Transcatheter Closure for Coronary Cameral Fistula in Pediatrics. Acta Cardiologica Sinica, 37(1), 58–64. https://doi.org/10.6515/ACS.202101_37(1).20200730B.