

# Pediatric Cardiac Critical Care Symposium and POCUS hands on Workshop at NICVD, Karachi on 28th August, 2024



Winfocus, Workshop at NICVD karachi.



Quiz Answer:  
Q. 1: C, Q. 2: A, Q.3: B, Q. 4: A, Q.5:C



# NEWSLETTER

Pakistan Association of Cardiothoracic Anaesthesiologists

## VIGILANCE ENSURE SAFETY

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## EDITORIAL

Assalam Alaikum,

This is our third Newsletter in 2024, published under the banner of the Pakistan Society of Anesthesiologists (PACTA). The theme of the current Newsletter is Congenital Heart Disease (CHD). The global incidence of CHD is about 0.8/per 1000 live births, but it is higher in low-income countries like Pakistan. These patients are facing multiple challenges like delayed diagnosis, management issues and deficiency of facilities, trained physicians, and staff. Availability of funds is also an issue as most of these children belong to low-income families. However, with PACTA and other associations' dedicated efforts, we hope for a brighter future. We have included important topics related to the theme and hope that you will find these topics interesting. I am grateful to all those who contributed, including the writers and reviewers.

The present and previous Newsletters are also available on the PACTA website ([www.pacta.pk](http://www.pacta.pk)). Please keep sending your feedback to improve the quality of this Newsletter.

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## RASTELLI Procedure with handmade expanded Polytetrafluoroethylene (PTFE) bileaflet valved conduit.

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## CASE PRESENTATION:

RA came to us last month, visibly blue, with room air saturation of 58% and barely able to walk 50 meters. He has been progressively worsening for the last few years and has stopped going to school. Presently, he is 16 years old, weighing 36kg. At the age of 3 years, he had a classic BT shunt (left subclavian artery anastomosed to left pulmonary artery) in Peshawar. His birth diagnosis was Pulmonary Atresia, large VSD and PDA-dependent pulmonary blood flow. Recently, he was investigated in Peshawar with Echocardiography and Cardiac CT, which was reported to have the anomalous origin of the right coronary artery from the left coronary sinus and a large Conal branch crossing RVOT parallel to LAD. The family consented to the following;

**Option No.1** Rastelli Procedure.

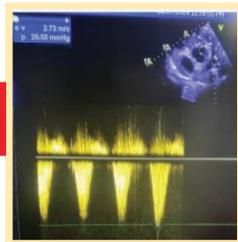
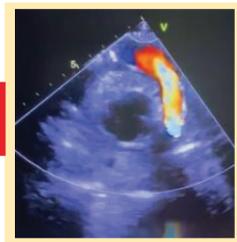
**Option No.2** Add another BT/ systemic to pulmonary shunt in case the abnormal coronary anatomy does not permit placing a conduit on the RV.



Figure 1,PTFE RV to PA conduit



Figure 2: Classic BT shunt



We used handmade valved conduit in our patient. We made the conduit using an 18mm Gore-Tex tube graft (GoreTex; W.L. Gore & Associates, Flagstaff, Arizona 86004, USA). The bileaflet valved was constructed using 0.1mm GoreTex membrane according to Kobe's children hospital Japan technique (1).

After opening the pericardium, we found a reasonable distance between the large conal branch of RCA and LAD to accommodate proximal anastomosis of the conduit. Ligation of the left-sided Classic BT shunt was done in the left pleural space, medial to the hilum of the left lung (Figure 2). Cardiopulmonary bypass was instituted with bicaval venous cannulation with aortic root return. Core cooling to 28 C was employed. VSD was tunneled to aorta with a Suvage (Woven Nylon) patch and our homemade conduit was employed to establish RV to PA connection. Bypass time was 178 minutes, and cross-clamp time was 150 minutes.

Postoperative echo showed a well-functioning bi-leaflet RV to PA conduit with no stenosis or regurgitation and no residual VSD (Figure 3). The patient was extubated after overnight ventilation. He remained in the ICU for three days and made an uneventful recovery. He was discharged home on the eighth postoperative day.

**Figure 3:** RV to PA conduit color Doppler.

## DISCUSSION

This is our fourth patient for whom we have used a bileaflet Gortex valve in a Gortex tube. Early post-operative outcomes have been excellent in all cases.

Establishing RV to PA connection with preferably a valved conduit is an integral part of various surgical procedures in neonates and young infants to repair congenital cardiac defects. Due to the lack of prefabricated conduits, handsewn valve conduits are a reasonable alternative option for congenital heart surgeons in Pakistan. In the Children's Hospital, Lahore hand sewn conduit using bovine pericardium and a "tri leaflet" valve made of Gortex membrane (0.1mm thick) has been used for many years (3). At Bahria International Hospital Orchard Lahore, we have adopted the bileaflet valve conduit for such procedures. These are handsewn valved conduits of E PTFE with Gortex membrane bileaflet valve as devised by Koebe Children's Hospital, Japan (2). In our experience the bileaflet valve are easy to fabricate and reproducible for various sizes.

## CONCLUSION

RV to PA valved conduits are Achilles heel in various congenital heart surgery procedures. Lack of growth and loss of a competent valve is another part of the problem. It is challenging to obtain pre-fabricated valve conduits in Pakistan. Moreover, their prices are prohibitively high. Only time will tell us about the long-term patency in PTFE grafts with the Gortex bileaflet valve. Though Children's Hospital Lahore, in their publication, has claimed good valve patency in follow up of 3 to 5 years.

## Reference

1. J Thorac Cardiovasc Surg. 2024 Feb; 167(2):439-449.e6. doi: 10.1016/j.jtcvs.2023.05.043. Epub 2023 Jun 24. [https://www.jtcvs.org/article/S0022-5223\(23\)00532-9/fulltext](https://www.jtcvs.org/article/S0022-5223(23)00532-9/fulltext).  
2. <https://pjmhsonline.com/2020/apr-june/1598.pdf>

## QUIZ CORNER

### Question # 1: Which of the following affects a sound wave's propagation velocity?

A. Signal frequency

B. Signal amplitude

C. Tissue density

D. Transducer size

### Question # 2: Sound waves propagate in all of the following except?

A. Vacuum

B. Blood

C. Bone

D. St. Jude mitral valve

### Question # 3: The speed of sound in soft tissue is approximately?

A. 1500 cm/s

B. 1500 m/s

C. 1500 km/h

D. 1500 mph

### Question # 4: Which statement regarding coronary topographic anatomy is true ?

A. The left main coronary artery runs in the atrioventricular sulcus between the pulmonary trunk and the left atrial appendage

B. In the midesophageal short axis view of the aortic valve, the right coronary ostium is seen in the middle of the right coronary cusp at the 9 o'clock position

C. The marginal branches of the left circumflex coronary artery supply the interventricular septum

D. The coronary sinus runs along the anterior atroventricular groove and drains into the right atrium

### Question # 5: Which statement regarding coronary blood supply is true?

A. The inferolateral segments of the LV are always supplied by the right coronary artery

B. The anterolateral segments of the LV are always supplied by the left circumflex coronary artery

C. The anterior segments of the LV are always supplied the left anterior descending coronary artery

D. The anteroseptal wall of the RV is always supplied by the right coronary artery

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\*Answers on the last page

# RECENT MANAGEMENT STRATEGIES IN PATIENTS WITH PULMONARY HYPERTENSION

## Defination:

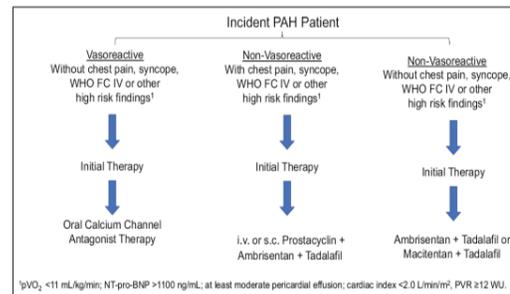
The definition of pulmonary hypertension (PH) has changed recently based, in part, on contemporary outcome data and to focus on early disease detection. Patients with mean pulmonary artery pressure >20 mm Hg measured by right heart catheterization. In contrast to the classical era, pulmonary vascular resistance >2.0 Wood units is also used for diagnosis and prognostication. These lowered thresholds aim to identify patients early in the disease course, which is important because delay to diagnosis of PH is common and linked to elevated morbidity and shortened lifespan. Outcomes through evidence-based medicine and research-informed practice.

Definition	Hemodynamic profile	Typical clinical group
PH	mPAP >20mmHg	All
Precapillary PH	mPAP >20mmHg PVR >2 WU PAWP ≤15mmHg	Pulmonary arterial hypertension PH attributable to lung disease CTEPH
Combined precapillary+postcapillary PH	mPAP >20mmHg PVR >2 WU PAWP >15mmHg	Left heart disease Left heart+lung disease overlap
Isolated postcapillary PH	mPAP >20mmHg PVR ≤2 WU	Left heart disease
Exercise PH	mPAP/CO slope between rest and exercise >3mmHg/L per min	Exertional dyspnea with preserved LV ejection fraction with normal resting PAWP

(Chronic Thromboembolic pulmonary hypertension CTEPH)

## Recent Management Strategies:

1. Targeted Therapies: Phosphodiesterase-5 inhibitors (e.g., sildenafil), endothelin receptor antagonists (e.g., bosentan), and prostacyclin analogs (e.g., epoprostenol) have been shown to improve exercise capacity, hemodynamics, and survival in PH-CHD patients.
2. Catheter-Based Interventions: Balloon pulmonary angioplasty and stenting can help relieve pulmonary artery stenosis and improve blood flow.
3. Surgical Interventions: Pulmonary artery reconstruction, shunt closure, and heart-lung transplantation may be necessary in advanced cases.
4. Multidisciplinary Care: Collaboration between cardiologists, Pulmonologists, Anesthesiologists and Surgeons is crucial for optimal management.



## Approach to the management of patients with incident pulmonary arterial hypertension (PAH).

Newly diagnosed patients with idiopathic, hereditary, or drug-induced PAH should be considered for vasoreactivity testing in the cardiac catheterization laboratory at an expert pulmonary hypertension center. In the absence of a high-risk clinical profile, patients who demonstrate a positive vasoreactivity response, defined by decrease in mean pulmonary artery pressure ≥10 mm Hg from baseline to ≤40 mm Hg without a decrease in cardiac output, should be initiated on calcium channel antagonist therapy dose titrated to optimal clinical benefit/adverse effect balance.

For patients with PAH without evidence of vasoreactivity but with high-risk findings, consideration to up-front therapy with the prostacyclin analogue treprostinil administered by intravenous (i.v.) or subcutaneous (s.c.) route plus the phosphodiesterase type-5 inhibitor tadalafil and endothelin receptor antagonist ambrisentan is indicated.

For patients with PAH without vasoreactivity or high-risk findings, initial combination therapy with the tadalafil and ambrisentan or the alternate endothelin receptor antagonist macitentan should be considered.

## Reference

1. Galie et al. (2019). 2019 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. European Heart Journal, 40(17), 1341-1364.
2. Stout et al. (2020). Pulmonary hypertension in congenital heart disease: A review of the current management strategies. Journal of Clinical Medicine, 9(11), 3521.
- 3) Bradley A. Maron, MD J Am Heart Assoc. 2023; 12:e029024. DOI: 10.1161/JAHA.122.029024

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# IMPLEMENTATION OF A CONTINUOUS QUALITY ASSURANCE PROGRAM TO REDUCE SURGICAL SITE INFECTION

Surgical site infections (SSIs) following cardiac surgery remain a significant challenge for healthcare systems worldwide. Despite advancements in surgical techniques, aseptic practices, and antibiotic prophylaxis, SSIs continue to plague this patient population, posing a substantial burden on individual well-being and healthcare resources. This introductory note delves into the current landscape of SSIs in cardiac surgery, exploring their incidence, mechanisms of infection, and the cascade of potential complications that can significantly impact patient outcomes. Studies report a wide range of SSI incidence rates following cardiac surgery, varying between 1% and 5%.(1) This disparity can be attributed to specific surgical procedures, patient demographics, and variations in how SSIs are defined and diagnosed. Currently, the median incidence of SSI per the International Quality Improvement Collaborative for Congenital Heart Surgery is less than 2.4%. (2).

The Department of Cardiothoracic Sciences was established at the Sindh Institute of Urology and Transplantation (SIUT) in June 2022 and the first open heart surgery was performed in April 2022. Since then, more than 500 procedures have been performed, including cardiac surgeries, thoracic surgeries and cath. lab interventions.

Three months into the program, we saw a sudden rise in the incidence of surgical site infection. Being a special cause variance in our data set, specific actions were taken to minimize it as it could lead to higher morbidity, longer hospital stay, and higher mortality. To achieve our target of an infection rate of less than 2.4%, we established a continuous quality improvement (CQI) program to look into the intricacies of possible causes and how to prevent them in the future.

## Methods:

This CQI project was conducted in the cardiothoracic science division at SIUT. On average, 25 to 30 cardiac surgeries, eight thoracic surgeries and 20 cath lab procedures are being conducted each month. The department comprises one cardiac surgeon, a thoracic surgeon and four cardiologists. A smart aim and global aim were made around which key drivers were chosen. These key drivers were based on a series of interventions. Fig. 1 shows the Key Driver Diagram.

Taking the surge of SSI as a special cause variance in our data set, we ran a Plan-Do-Study-Act (PDSA) cycle to understand the root cause of this issue, broaden our perspective about surgical site infections, and collaborate with other teams to learn their methods of combating it. This is shown in Fig 2.

An essential element of this study was to set up a nurse-led wound clinic, which not only helped us track every patient but also helped us identify infections early. Each patient is given instructions on wound care before discharge. The wound is cleaned and dressed in front of the patients so as to teach them how to take care of it at home. Each patient is asked to visit the wound clinic once a week for 30 days. Patients who live in remote areas can communicate with the wound nurse over the phone and share images to get a consultation.

To achieve our goal further, we created a set of process metrics for each of our interventions to define our processes and make them measurable and achievable. These are shown in Tables 1 and 2.

Following several interventions, the CQI team achieved a sharp decline in the rate of surgical site infections, as shown in the trend graph (Fig 3).

## Conclusion:

Surgical site infections are one of the most devastating morbidities, leading to an increase in healthcare costs, delayed discharge from the hospital, prolonged antibiotics, and the possibility of multiple surgeries. Taking immediate action against this problem and taking a systematic approach to achieving our goal has helped us reduce the rate significantly.

A continuous quality initiative such as this is necessary to curb and sustain the drop in SSI.

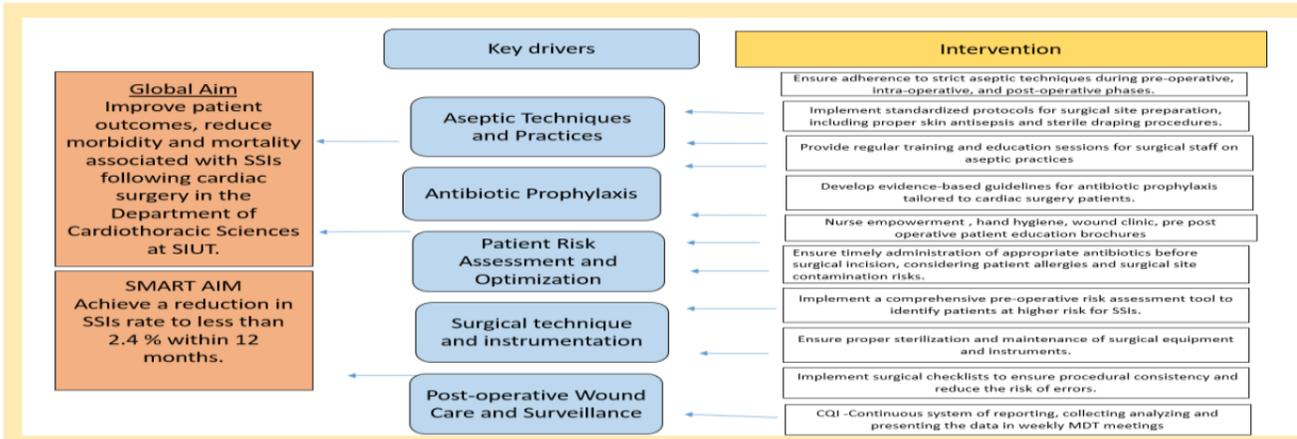


Figure 01

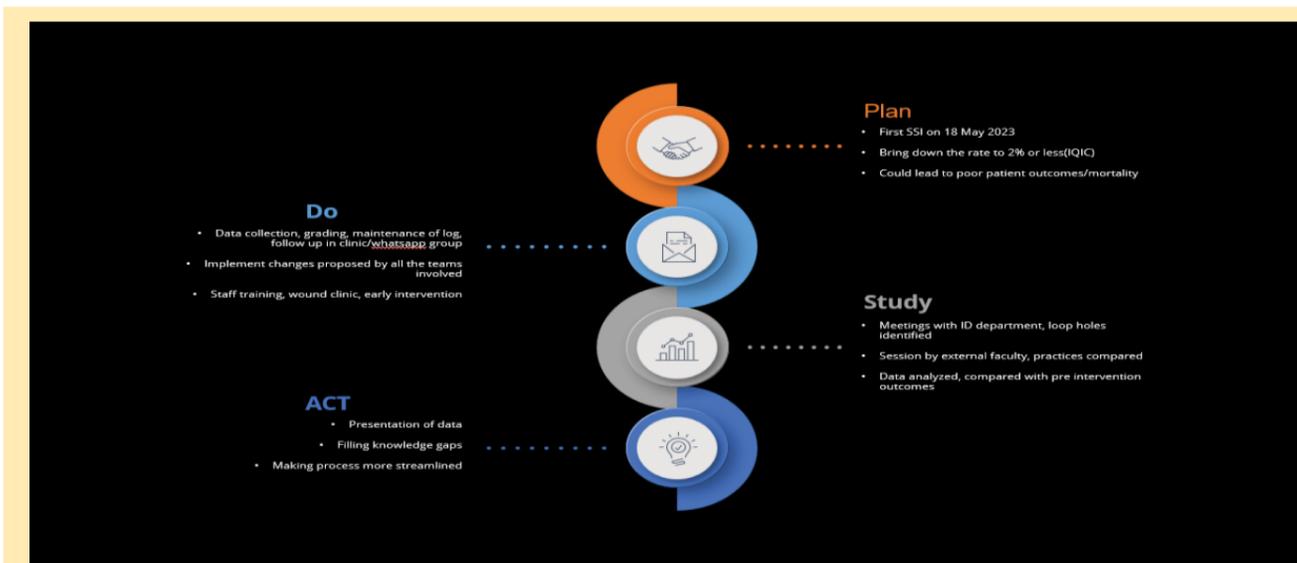


Figure 01

Intervention	Process metric	Definition	Method	Target
Aseptic techniques an practices	Compliance rate with aseptic techniques	Percentage of staff adhering to established aseptic protocols during pre-operative, intra-operative, and post-operative phases	Direct observation, checklist audits Number of people with 100 % compliance/ number of employees Check list: 5 moments of hand hygiene. (graph of hand hygiene)	100 % compliance
Training of Staff	Training completion rate	Percentage of nursing and OR technician staff completing regular training and education sessions on aseptic practices	Training logs, attendance records	80 %
Antibiotic Prophylaxis	Timeliness of Antibiotic Administration	Percentage of patients receiving antibiotics within the appropriate time frame before surgical incision.	Number of cases received antibiotics/Total number of surgeries	100 %
Patient Risk Assessment and Optimization	Pre-operative Risk Assessment Completion using tool kit ( table -1)	Percentage of patients undergoing comprehensive pre-operative risk assessment.	1.Number of patients with risk stratification /number of surgeries 2.Number of patient risk optimized/ total number of high risk identified for SSI	100%

Table 01

Intervention	Process metric	Definition	Method	Target
Standardization of Surgical Techniques	Standardization of Surgical Techniques and compliance rate	Percentage of surgical procedures following standardized techniques and using standardized instruments	Surgical checklists, direct observation. Sterilization logs, equipment maintenance records	100 %
Wound care	Post-operative Wound Care Adherence and wound infection surveillance rate	Percentage of patients receiving standardized post-operative wound care	Number of patients complaint/ total number of surgeries	95%
Quality audit	Data Collection and Analysis Frequency, CQI Team Meeting Frequency	Frequency of data collection and analysis on SSI incidence rates.	Monthly analysis., CQI weekly meeting Number of CQI MEETINGS/ NUMBER OF WEEKS / MONTH	80% Monthly CQI meeting
Quality control	• Root Cause Analysais (RCA) of grade 2 and 3 SSI • RCA of special cause variance	Number of RCAs conducted per identified SSI case.	RCA reports- Number of RCA of 3 -4 / total grade 2-3 SSI  Number of SCV RCA/ Total number of SCV	100 %
Divisional quality audit meeting ( SWIM )	Staff Engagement in Improvement Activities	Percentage of staff actively participating in QI initiatives.	Participation records.	9o %

Table 02

Reference

- Li Z, Huang Z, Xu J, et al. Surgical Site Infection in Cardiac Surgery. BioMed Research 2019; 2019: 1-9. [PMC6788857]
- Balachandran, R., Kappanayil, M., Sen, A. C., Sudhakar, A., Nair, S. G., Sunil, G. S., Raj, R. B., & Kumar, R. K. (2015). Impact of the International Quality Improvement Collaborative on outcomes after congenital heart surgery: a single centre experience developing economy. Annals of cardiac anaesthesia, 18(1), 52–57. <https://doi.org/10.4103/0971-9784.148322>

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## PEDIATRIC CONGENITAL HEART DISEASE PATIENT PRESENTING FOR NON-CARDIAC SURGERY: IMPORTANT CONSIDERATIONS FOR NON-CARDIAC ANESTHETISTS

Perioperative cardiac arrest registry (POCA) data indicates that 34% of all Anaesthesia-related pediatric cardiac arrests occurred in patients with heart diseases, and 50% of these arrests were during Anaesthesia for non-cardiac surgeries. The global prevalence of congenital heart disease (CHD) at birth is estimated to be nearly 0.8 – 1.2 cases per 100 live births, with a higher incidence in Asian countries. This underscores the need for expertise in managing these cases. The most common non-cardiac procedures are Gastrointestinal and Otolaryngological procedures. The risk of complications is higher in children less than one-year-old<sup>1</sup>.

Although there are several classifications of CHD, but these patients can be simply classified into Cyanotic and Acyanotic heart diseases. Cyanotic CHD patients include TOF, TGA, TAPVR, and tricuspid atresia. These patients usually have chronic hypoxemia, Polycythemia, Coagulation abnormalities, and ventricular dysfunction. Three categories of CHD patients may visit the preoperative clinic.

### 1. Uncorrected CHD

### 2. Patients with palliative surgery (BT shunt, Glenn shunt, Fontan procedure)

### 3. Total correction of CHD (With or without residual defects)

### Preoperative evaluation:

It is crucial and should focus on understanding the cardiac defect, altered physiology, and Pulmonary HTN. This includes assessing the extent of pulmonary flow, the degree of hypoxaemia, Polycythaemia, and Coagulation abnormalities, as well as identifying any associated pathophysiological findings that will influence management.

Ask about dyspnoea when feeding or running and assess for failure to thrive. The degree of cyanosis should be evaluated. Room air SaO<sub>2</sub> should always be checked to assess the severity of the disease.

CBC, PT, and APTT should always be checked in patients with CHD who are coming for any procedure. Polycythaemia poses a risk of thrombosis, and phlebotomy should be considered in patients with Hct >65%. Always check chest X-ray for heart size, dextrocardia and pulmonary vascular markings. Prominent vascular markings indicate high pulmonary flow, while diminished markings indicate low pulmonary flow.

It's essential to be aware that specific syndromes are also associated with CHD, such as Down's syndrome, Di George's, Noonan's syndrome, VATER association and Treacher-Collins syndrome. These syndromes may present additional health issues that need to be considered in the anaesthetic management plan.

### Preoperative orders

Hydration status is particularly relevant in patients with cyanotic lesions, Fontan's, Aortic stenosis, and other defects for which ventricular preload is essential for maintaining cardiac output. Fasting times should be carefully planned. More than six months of CHD patients must be sedated at the time of separation from their parents. Crying and struggling increases oxygen consumption and further deteriorate hypoxaemia.

AHA recommends prophylactic antibiotics for endocarditis in the following conditions:

#### 1. H/O infective endocarditis

#### 2. Unrepaired cyanotic congenital heart disease (CHD), including shunts and conduits

#### 3. Repaired CHD with residual shunts or valvular regurgitation at the site or adjacent to the site of a prosthetic patch or prosthetic device

### Procedural sedation:

CHD patients are frequently admitted for dental, radiology and cardiac catheterization procedures, and anaesthetists are asked to provide sedation. Propofol is commonly used for these procedures despite its significant depressant effect on the cardiovascular and respiratory systems. Hypotension due to propofol use in patients with TOF may lead to reversal or an increase in right to left shunt. Dexmedetomidine infusion is a good choice in patients with marginal cardiac reserve as it does not cause myocardial suppression. Chloral hydrate is an effective medication but has a longer half-life due to the active metabolite trichloroethane, particularly in preterm infants. Ketamine is the drug of choice in patients who require minor and short procedures, but its use in patients with pulmonary HTN is controversial.

## INTRAOPERATIVE MANAGEMENT

### General Care:

Intravenous line must be placed in all CHD patients, even for minor procedures. All intravenous tubing should be free of air bubbles. Inhalation induction is well tolerated by most patients except those with poor cardiac function. Patients with congestive heart failure or with poor cardiac reserve should be optimized before surgery. In these patients' inotropes may be started or continued, and patients induced with intravenous agents. Avoid N<sub>2</sub>O as it increases PVR and may exacerbate air embolus.

### Polycythaemia patients:

are prone to coagulopathy, for which blood products should always be considered. In addition, polycythaemia symptoms are aggravated by dehydration, due to which fluid management during the perioperative period becomes critical.

### Pulmonary HTN:

The risk of pulmonary HTN is high in children with CHD. Persistent large L – R shunt (ASD, VSD, AVSD, truncus arteriosus) leads to high pulmonary flow and pulmonary vascular changes, while restricted smaller shunts may not produce pulmonary HTN. Pulmonary vascular disease can also occur in children with pulmonary venous obstruction, as in TAPVC, mitral stenosis. Children with Pulmonary HTN are at risk of sudden death and RV failure. Pulmonary vascular bed becomes highly reactive to hypoxia, hypercarbia, acidosis and pain. High PVR may also trigger bronchospasm. Hyperventilation is the most reliable way to reduce PVR. It is the PH, not CO<sub>2</sub>, which affects the PVR

### Hypoxaemia:

Is very common in CHD patients mainly due to three reasons. Firstly, decreased pulmonary flow to the lung may occur in certain heart diseases (pulmonary stenosis, TOF). Try to avoid further increases in PVR in these patients and maintain adequate volume. Secondly, increased pulmonary blood flow (L – R shunt) can also lead to pulmonary congestion and inefficient gas exchange at later stages of the disease. The third cause of hypoxaemia is mixing oxygenated and deoxygenated blood in cardiac chambers. 100% O<sub>2</sub> to these patients may lead to pulmonary VD and increase pulmonary flow at the expense of decreased systemic flow

### Bleeding and thrombosis risk:

Patients with severe cyanosis and room air SaO<sub>2</sub> less than 85% usually have coagulation abnormalities, excessive bleeding, Polycythemia and thrombosis risk. APTT and INR may be increased, but that do not protect against thrombosis.

### Reference

1. Van der Linde D, Konings EEM, Slager MA, et al. Birth prevalence of congenital heart disease worldwide. J Am Coll Cardiol. 2011; 58:2241–2247.)
2. Perioperative Considerations for Paediatric Patients With Congenital Heart Disease Presenting for Non-cardiac Procedures: A Scientific Statement From AHA. Nasr et al. Circ Cardiovasc Qual Outcomes. 2023

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# CARDIAC CATHETERIZATION IN CONGENITAL HEART DISEASE

Cardiac catheterization in the paediatric population has similarities with catheterization in adults but distinct differences. In adults, the primary pathology is isolated coronary artery disease and valvular disease. The indications, techniques, and interventions performed in paediatrics are different. Broadly speaking, cardiac catheterization in the context of congenital heart disease is either diagnostic or therapeutic. Traditionally, cardiac catheterization was the primary tool in diagnosing and evaluating congenital heart disease. Before the emergence of echocardiograms, clinical suspicion of congenital heart disease required a cardiac catheterization for definitive diagnosis, possible intervention, and pre-surgical planning.

## Diagnostic cardiac catheterizations:

Cardiac catheterization can provide information such as angiographic images by fluoroscopic imaging during contrast injection, pressure measurements, oxygen saturations, and estimations of cardiac output and pulmonary vascular resistance. Pressure measurements are taken by a fluid-filled pressure transducer attached to a catheter that is passed through various chambers in the heart (Figure 1). The transducer produces cardiac pressure waveforms (Figure 2). This is especially important in the evaluation of stenosis, diastolic dysfunction, and pulmonary vascular resistance.

Oxygen saturation is also measured in each chamber of the heart. Based on the Fick Principle, this data is then used to estimate a patient's cardiac output and the ratio of pulmonary to systemic blood flow (Qp:Qs). Cardiac output = Oxygen consumption/ Oxygen content difference.

Oxygen consumption is often estimated based on normal values in older children and adults. The oxygen content difference is primarily the product of the change in haemoglobin saturation and the oxygen-carrying capacity of haemoglobin.

**Oxygen content difference = 1.36×hemoglobin×difference in oxygen saturations.**

This way, sampling blood in the systemic veins and aorta can estimate cardiac output. Similarly, sampling blood in the pulmonary arteries and pulmonary veins can estimate pulmonary blood flow.

Resistance calculations are then based on Ohm's law of electromagnetism. According to this law, the electric current through a conductor is directly proportional to the potential voltage difference divided by the resistance. Modified for body fluid dynamics, it simply states that.

**Resistance= ΔPressure/ Flow (Qp)**

Δ Pressure: mean PA pressure- mean LA pressure.

Pulmonary blood flow is estimated by the Fick Principle.

Ohm's law is used for calculating pulmonary vascular resistance (PVR), which is an essential measure in the diagnosis and management of pulmonary hypertension and pre-surgical planning.

## Therapeutic or Interventional procedures:

There is a wide range of therapeutic procedures performed in the congenital catheterization lab, including device closure of septal defects, balloon angioplasty of stenotic lesions and valvuloplasty of stenotic valves, stenting for vascular stenosis, embolization and device closure of vessels, even percutaneous pulmonary valve implantations. The equipment and tools of an interventional cardiologist varies based on experience level and new technological innovations. Various devices are available for septal defect closure and to embolize or close vessels. The critical thing to remember is that the evaluation of suitability for device closure is essential and involves a transesophageal echocardiogram. Pulmonary and aortic valve balloon dilatations are the treatment of choice for respective valve stenosis with excellent results. An inflatable and deflectable balloon is essential in the treatment of valve stenosis and the deployment of stents. These specialized balloon catheters are inflated with a contrast solution, making them easily visible on fluoroscopy.

Each stent has its own set of characteristics, including size, strength, and "shortening" ability (Figure 3). Stents are metal or plastic mesh tubes loaded over balloon catheters and expandable inside a vessel. Covered stents have a surgical fabric coating that creates a contained tube that is expandable, similar to bare stents. Indications include stenotic lesions that are unresponsive to balloon dilation or recur frequently. Additionally, covered stents are used to treat significant tears or aneurysms.

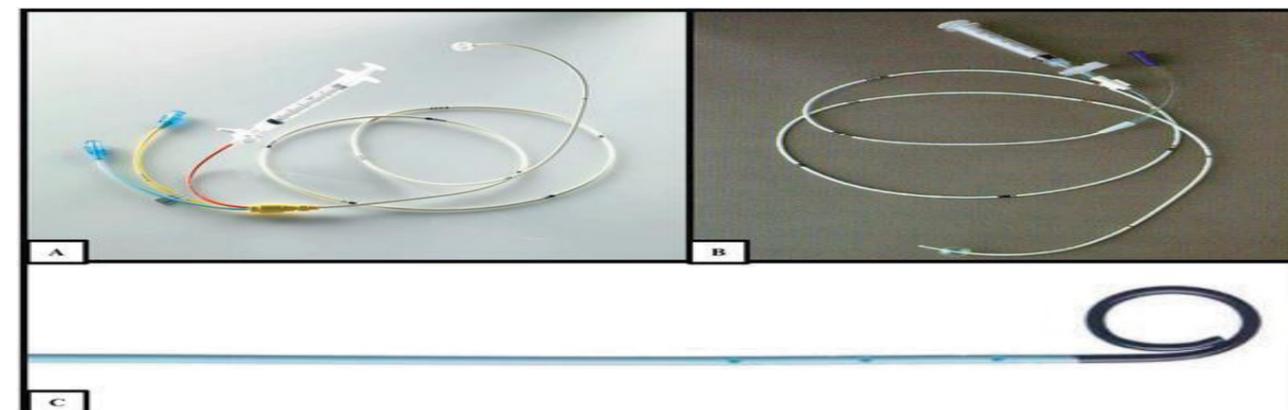


Figure 1: Various cardiac catheters. (A) A thermodilution catheter used to calculate cardiac output. (B) A Berman catheter with an inflatable balloon and side holes is a multiuse catheter. (C) A pigtail multiuse catheter. The multiple side holes allow for angiography of arterial vessels.

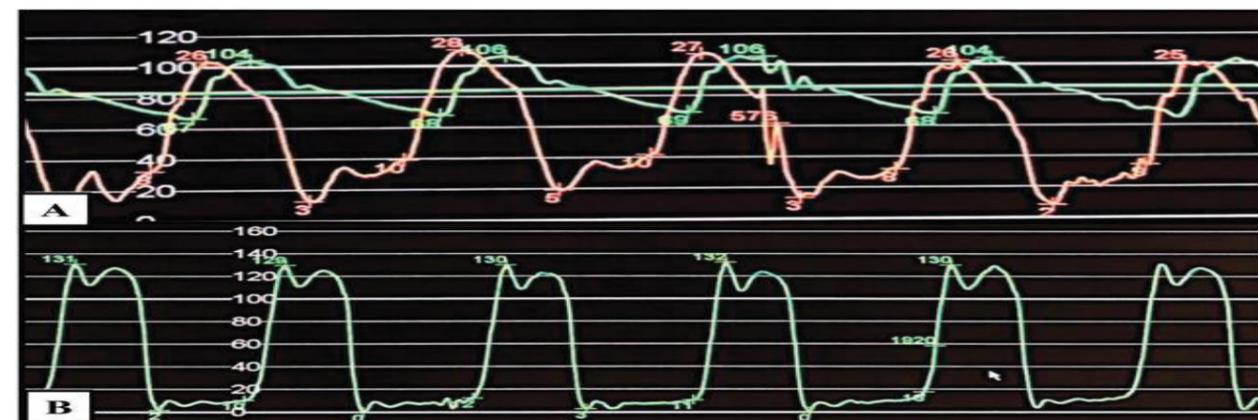


Figure 2: Normal intracardiac pressure tracings in a 10 year old patient. (A) A simultaneous pressure tracing of the right ventricle (red) and the femoral artery (green). (B) Pressure tracing of the left ventricle.

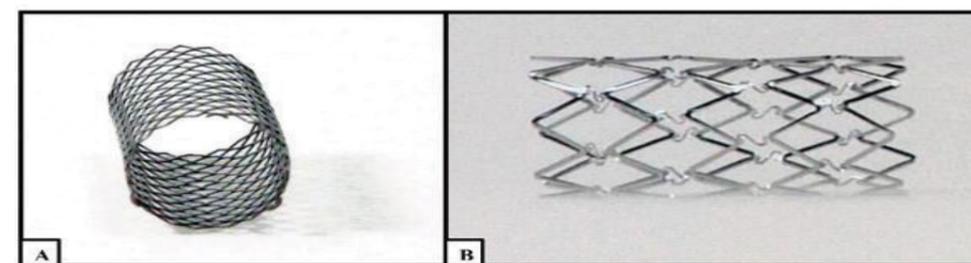


Figure 3: Two different kinds of bare metal stents

## Reference

Fick A. Ueber die Messung dea Blutquantums in den Herzventrikela. Seitung der Physikalisches und Medicinisches Gesellschaft zu Würzburg. 1970;2:290-291  
Devanagondi R, Peck D, Sagi J, Donohue J, Yu S, Pasquali SK, et al. Long-term outcomes of balloon valvuloplasty for isolated pulmonary valve stenosis. Pediatric Cardiology. 2017; 38:247-254.

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