OUTCOME OF TOTAL CORRECTION FOR ISOLATED TOTAL ANOMALOUS PULMONARY VENOUS CONNECTION: A RETROSPECTIVE STUDY

PROJECT
BY

DR. SHIVANG SAXENA

MCh. CARDIOTHORACIC VASCULAR SURGERY
RESIDENT
2018-2020

DEPARTMENT OF CARDIOTHORACIC VASCULAR SURGERY
SREE CHITRA TIRUNAL INSTITURE FOR MEDICAL SCIENCES AND TECHNOLOGY, TRIVANDRUM
KERALA, INDIA-695011

CERTIFICATE

This is to certify that this thesis entitled "**Outcome of total correction for isolated total anomalous pulmonary venous connection: A retrospective study**" has been prepared by **Dr SHIVANG SAXENA,** MCh CVTS resident, Department of Cardiovascular and Thoracic Surgery at Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram. He has shown keen interest in preparing this project.

(GUIDE)

Dr. Sabarinath Menon

Additional Professor

Department of Cardiovascular and thoracic surgery, SCTIMST, Thiruvananthapuram

(CO GUIDE)

Dr. Baiju S Dharan

Professor & Head

Department of Cardiovascular and Thoracic Surgery, SCTIMST, Thiruvananthapuram

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Place: Thiruvananthapuram

Date : 29/8/20

Professor Baiju S Dharan

Professor and Head

Department of Cardiovascular and thoracic surgery,

SCTIMST, Thiruvananthapuram

DECLARATION

I hereby declare that thesis entitled "Outcome of total correction for isolated total anomalous pulmonary venous connection: A retrospective study" has been prepared by me under the guidance of Additional Professor Dr Sabarinath Menon ,Professor Dr Baiju S Dharan ,Department of Cardiovascular and Thoracic Surgery at Sree Chitra Tirunal Institute For Medical Sciences And Technology,TRIVANDRUM

Date: 29/8/20.

Place: SCTIMST, Trivandrum

DR SHIVANG SAXENA
MCh CVTS RESIDENT
DEPARTMENT OF CARDIOVASCULAR AND
THORACIC SURGERY
SCTIMST,THIRUVANANTHAPURAM

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(GUIDE)

Dr. Sabarinath Menon

Additional Professor

Department of Cardiovascular and thoracic surgery, SCTIMST, Thiruvananthapuram

(CO GUIDE)

Dr. Baiju S Dharan

Professor & Head

Department of Cardiovascular and Thoracic Surgery, SCTIMST, Thiruvananthapuram

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It is a matter of great privilege for me to express my heartfelt gratitude and sincere regards to my Professor, Prof. Baiju S Dharan. (Professor and Head, Department of CVTS, Sree Chitra Tirunal Institute for Medical Sciences and Technology).Sir has been the source of constant inspiration and his teachings, his moral values, definitely will make me become a better human. His views on the subject and his expertise have been very encouraging throughout the study.

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SYNOPSIS

INTRODUCTION:

TAPVC(total anomalous pulmonary venous connection), is a relatively rare congenital heart disease in which all pulmonary veins (PVs) return into the systemic venous circulation because of connection failure between the PV and the primitive left atrium in the prenatal period.

Isolated TAPVC , amongst other congenital heart diseases has an incidence of 1-1.5%(1). Classification wise, TAPVC patients can be divided either on the basis of obstructed or unobstructed pulmonary venous return or on the basis of the level at which common chamber drains. TAPVC is supracardiac in about 45% of cases, cardiac in about 25%, infracardiac in about 25%, and mixed in about 5% to 10% (1).The pulmonary venous drainage is different in different types and holds significance during surgery.

As far as management is concerned, there has been a considerable change in management of isolated TAPVC cases in terms of surgical technique, myocardial protection techniques and this has translated into better post-operative outcomes. Current study aims at retrospectively analysing the impact of various preoperative ,intraoperative factors on immediate and late post-operative outcome for cases of isolated TAPVC.

MATERIALS AND METHODS:

The current study was conducted in a retrospective manner in department of cardiothoracic and vascular surgery ,SCTIMST, Trivandrum in a period from 1st January 2008 to 31st December 2018.Data was collected from hospital database. 242 patients who were operated for isolated TAPVC were included in this study. Pre-operative parameters like age, weight ,TAPVC anatomy and type, intra -operative pump parameters, type of surgery performed and post operative parameters like Vasoactive inotropic score, icu days ,post-operative complications and 5 year and 10 year follow up echo parameters were noted. Survival analysis was performed using Kaplan Meier and survival rate was compared across different groups.

RESULTS:

Majority of the patients operated were infants(64.88%) with a male to female ratio of 1.6:1.50 patients (20.66%) had weight less than 3 kg .These patients had significantly high

post operative inotropic score and icu days($p<0.001$).However eight didn't have significant impact on mid term and long term survival.

127 patients (52.4%) had supracardiac anatomy, 57 patients with cardiac type of TAPVC(23.55%),followed by 35 patients with infracardiac type of TAPVC(14.5%) and 23 patients with mixed type of TAPVC(10%).On reviewing the literature,it was found that these percentages are similar to that in previously published studies.Out of these almost all patients with infracardiac anatomy had obstructive type of TAPVC(97%).43% of the unobstructed type of TAPVC patients also had severe PAH.

Our surgical techniques were based upon the types of TAPVC.111(45.87%) patients underwent primary sutureless repair but the technique used didn't have any significant effect on mortality. There were total 20 mortalities in our study (9%) and 2 reinterventions.

CONCLUSION:

Total anomalous pulmonary venous connection (TAPVC) continues to remain the most common cause for emergency surgery in congenital heart surgery units world over. With the advent of early diagnosis, better surgical practices and use of pulmonary vasodilators both early and late surgical results have improved.

Presence of pulmonary venous obstruction is the single most important factor determining the overall survival. Weight less than 3 kilograms affects the early postoperative outcomes, but has no effect on overall survival. Primary sutureless technique for repair of TAPVC provides no additional benefit over the conventional technique in both early and late outcomes.

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INTRODUCTION

TAPVC(total anomalous pulmonary venous connection) is a relatively rare congenital heart disease (2)in which all pulmonary veins (PVs) drain into the systemic venous circulation because of connection failure between the PV and the primitive left atrium in the prenatal period (3).TAPVC is an entire spectrum where patients can present either as an isolated TAPVC or with associated complex cardiac anomalies, ranging from the presence of a ventricular septal defect (VSD) to the very complex heterotaxy syndromes. The outcomes depend on the associated anomaly as heterotaxy syndromes are associated with high morbidity and mortality(4).

Isolated TAPVC, amongst other congenital heart diseases, has an incidence of 1-1.5%(1). TAPVC patients can be classified either based on obstructed or unobstructed pulmonary venous return or based on the level at which common chamber drains to the systemic circulation. TAPVC is supracardiac in about 45% of cases, cardiac in about 25%, infracardiac in about 25%, and mixed in about 5% to 10% (1). The pulmonary venous drainage is different in different types and holds significance during surgery.

Early or late presentation of the patients depend upon the presence or absence of obstruction Obstructed TAPVCs is one of the few emergency operations in congenital heart disease patients (1). Pulmonary vein anatomy also varies from patient to patient, some having good natural size, some with small pulmonary veins, and some with common pulmonary vein atresia (CPVA). Pulmonary vein anatomy is an important factor deciding the postoperative prognosis of the patient. Postoperative outcomes are also associated with intraoperative anatomy, perfusion, surgical techniques, and timing of surgery(2). Surgical mortality in operated cases varies from as low as 2.5% to 10% or more(2).

Due to early referrals, improvement in pre-operative stabilization, and diagnostics to intraoperative techniques (surgical and myocardial protection) to postoperative management, early survival has improved to 95%(5). Thus, there has been a shift in the outcome analysis beyond the early postoperative period to midterm and long term survival, reintervention, and quality of life. Postoperative Pulmonary venous obstruction and pulmonary hypertension are the few serious complications associated with poor postoperative outcomes (6). Several additional factors are associated with perioperative morbidity and mortality and have been reported in the available literature. Age at operation, weight less than 3 kg, pre-operative anatomy and level of pulmonary venous obstruction (if any), intraoperative use of circulatory arrest, type of repair, are some variables studied in relation to the postoperative outcome of

the patients. Identifying risk factors affecting postoperative outcomes is essential for appropriate counselling (7) and care of the patients and decides the postoperative course for the patient.

The current study involves a retrospective analysis of isolated TAPVC patients who underwent repair at our institute between 1st January 2008 to 31st December 2018. The risk factors associated with the surgery and the postoperative outcome within this period were studied in retrospect. Survival analysis was done, keeping the risk factors in mind. Reinterventions, if any, have been accounted for and correlated with pre-operative anatomy to intraoperative technique.

REVIEW OF LITERATURE

Total anomalous pulmonary venous correction (TAPVC) is an essential anomaly of the pulmonary veins. It can be either associated with a biventricular heart or else with heterotaxy syndrome (4). TAPVC is known to present as elective and an emergency case. To date, it is one of the few emergencies in congenital heart surgery. It shows with admixture physiology (8) due to drainage of pulmonary venous blood into the systemic venous circulation.

First described by WILSON in 1798, the First successful repair was performed by Muller in 1951(9). TAPVC has an incidence of 0.6-1.2 per 10,000 live births and comprises 0.7-1.5% of all congenital heart diseases. It has a strong male preponderance (3:1) with most of the patients diagnosed during the neonatal period.

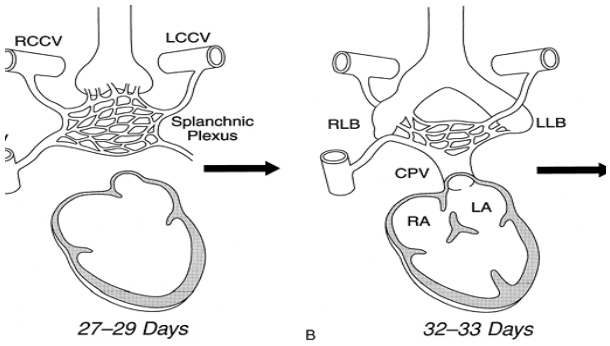
EMBRYOLOGY:

Pulmonary venous drainage between the 4th and 5th week of development is like a single structure (8), at the entrance into the sinus venosus (connecting the common atrium), bordered by the two muscular ridges, i.e., left and right ridge. These ridges are part of DMP (dorsal mesenchymal protrusion), mesenchymal cell accumulated, and responsible for atrial septation and encompasses primitive pulmonary vein. DMP is responsible for the shift of pulmonary vein towards the left side during atrial septation.

After atrial septation, common pulmonary vein drains into that part of sinus venosus incorporated into the posterior wall of the left atrium. Pulmonary vein bifurcates, dilates, and then merges into LA. By the end of the entire process, there are usually two right and two left pulmonary veins entering the LA.

NORMAL PULMONARY VENOUS EMBRYOLOGY:

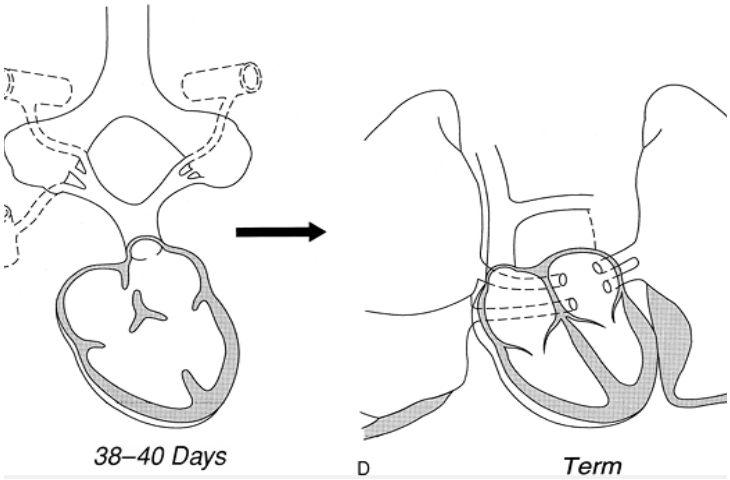
Embryologic development of pulmonary venous system



A: The pulmonary vascular bed is derived from the splanchnic plexus

B:Common pulmonary venous trunk connects to the primitive pulmonary venous system.

Embryologic development of pulmonary venous system



C: connections between the pulmonary venous plexus and the splanchnic venous plexus involute. D: common pulmonary venous trunk is absorbed into the left atrium so that the pulmonary veins are connected directly to the left atrium

FIGURE 1

TAPVC EMBRYOLOGICAL ASPECT:
This results due to failure to establish a connection between the pulmonary venous plexus and the common pulmonary vein before the connections with the splanchnic venous system have regressed.

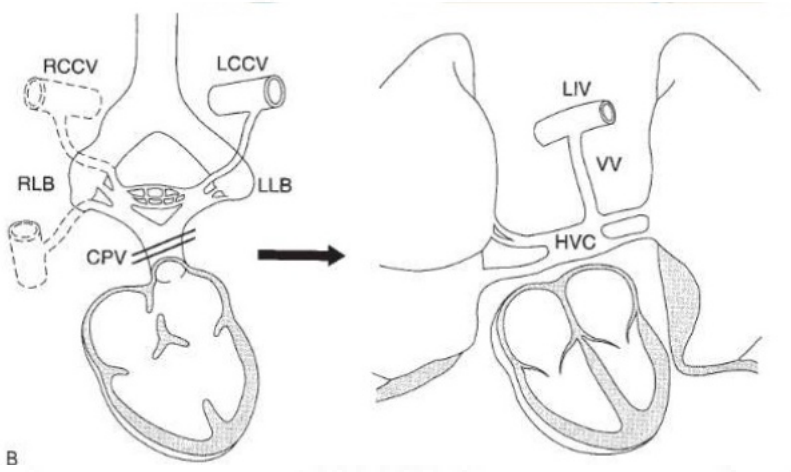


FIGURE 2

CLASSIFICATION:

Literature wise TAPVC has been classified in various ways(10).

Neills classification (1956) classifies according to embryology, dividing by connection to a) right atrium b) right common cardinal system (SVC and azygous vein) c) left common cardinal system (left innominate and coronary sinus) d) umblicovitelline system(portal vein and ductus venosus).

Darling and associates (1957) classified : TYPE I(anomalous connection at supracardiac level), TYPE II(the anomalous level at cardiac level), TYPE III(anomalous connection at infracardiac level), TYPE IV(anomalous connection at two or more of previous levels).

Burroughs and Edwards (1960) classification show the prognostic implication of length(long, intermediate, or short) of anomalous connection channel.

Smiths classification (1961)classifies TAPVC as supradiaphragmatic and infra diaphragmatic

Chowdhury classification of Mixed TAPVC:category 1(2+2 type,B/L symmetrical),category II(3+1 type,B/L and asymmetrical),category III(bizarre anatomic variant).

DARLING`S CLASSIFICATION

SUPRA CARDIAC-TYPE 1 a

- Most common(40%)
- 4 PVs→ CC → VV→ Lt innominate vein→ SVC
- VV pass anterior to LPA & Lt bronchus
- VV pass in b/w→ obstruction (VASCULAR VICE)

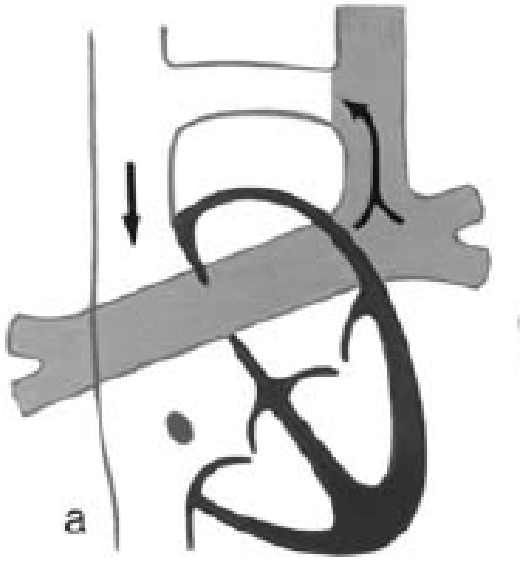


FIGURE 3

SUPRACARDIAC- TYPE 1 b

- 4 PV→ CPV→ VV→ SVC- RA jxn/ azygos vein
- More common in right atrial isomerism

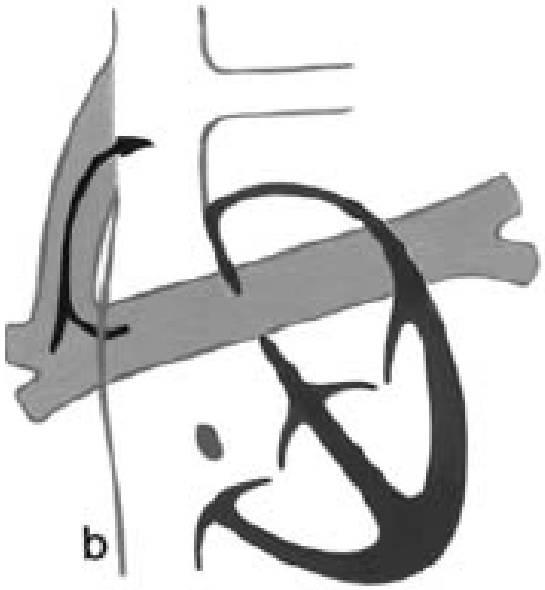


FIGURE 4

CARDIAC- TYPE II a

- Coronary sinus type- More common variant
- 4PVs→ CPV→ coronary sinus→ RA

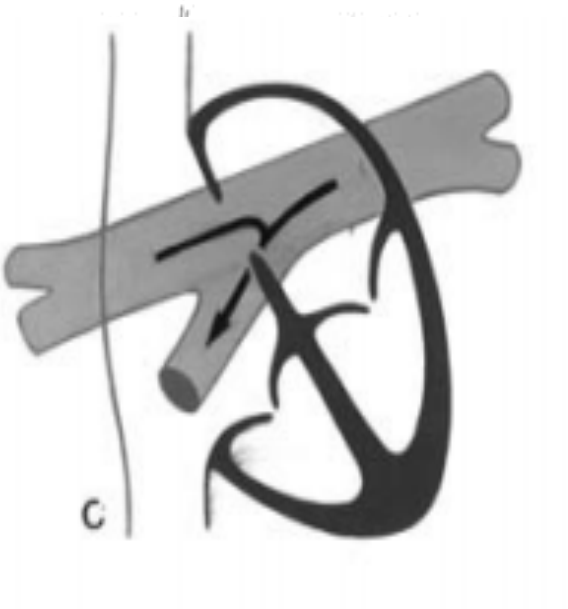


FIGURE 5

CARDIAC TYPE II b

- Right atrial type
- All 4 pulmonary veins drain directly to the RA

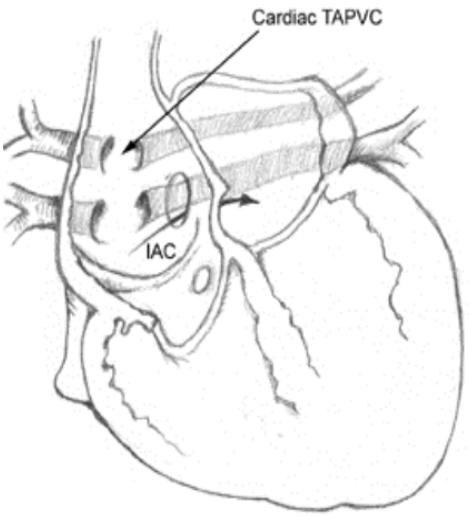


FIGURE 6

INFRA CARDIAC- TYPE III

- 4 PVs→ CC→ descending VV → esophageal hiatus → Portal vein (65%)/ Ductus venosus/ Hepatic vein / IVC

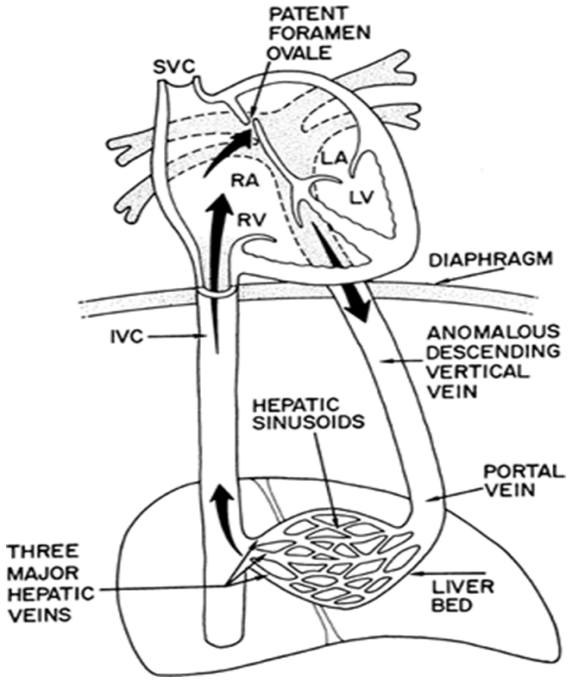


FIGURE 7

TYPE IV - MIXED

- A combination of any pathways
- Most common- supracardiac + cardiac

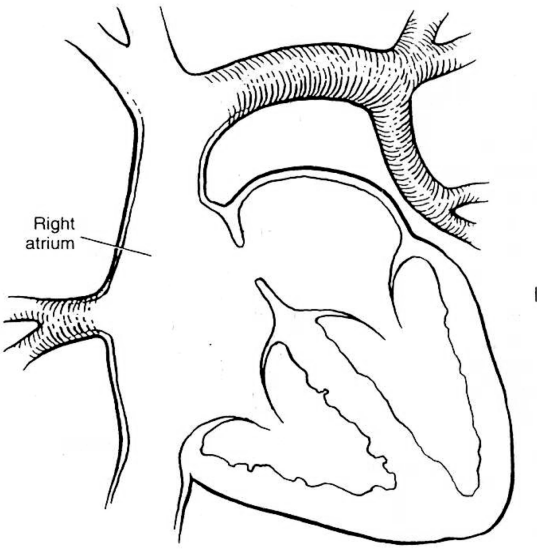


FIGURE 8

Prevalence wise ,45% of TAPVC are supracardiac ,25% cardiac and 25% infracardiac(1). Patients with TAPVC can develop pulmonary venous obstruction at any point in the anomalous venous pathway. The presence of an obstruction profoundly influences the hemodynamic state and clinical presentation of the patient. There are different sites of obstruction in TAPVC patients-a) restricted ASD, i.e., at the level of interatrial septum b)anomalous venous channel-intrinsic narrowing of the walls or by extrinsic compression, c)at the level of hepatic sinusoids(10).

When pulmonary venous obstruction is present, there are usually morphological changes in pulmonary arterioles and obstructed veins with an increase in arterial muscularity. Pulmonary veins are thick-walled and undergo intimal fibrosis. The small size of pulmonary veins at the time of presentation is predictive of subsequent progressive obstruction of pulmonary veins. Specific severity score for pulmonary vein stenosis has been used to assess the severity of stenosis with scoring from 0 to 4,0 being no stenosis and 3 being atretic or occluded (11).

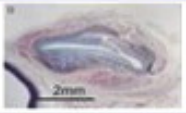
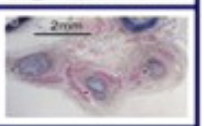
Score	Echo 2D Stenosis	Doppler gradient (Mean - mmHg)	Operative Findings (Macroscopic)	Pathology (Microscopic)
0	None	< 2	Normal Appearance	
1	Mild to Mod	< 5-6	3-4 mm	
2	Severe	> 7	< 2 mm	
3	Occlusion	None	No Lumen	

FIGURE 9

TAPVC PHYSIOLOGY:

TAPVC is admixture physiology with all pulmonary venous blood draining into the right atrium. Therefore, without mixing of the right side and left side blood, survival will not be possible.

- During the fetal period, pulmonary blood flow is small. Therefore the combined systemic and pulmonary venous blood to the right atrium is minimally increased(12). Hence, the stimulus for developing large interatrial communication is minimal. As the fetus transitions to neonate, there is a drop in pulmonary vascular resistance, and pulmonary over circulation occurs. However, the presence of widely patent ASD allows free communication between the two atria and thus unloading of the right side circulation. The mixed venous blood distribution depends upon the relative compliance of the atria and the ventricles and pulmonary and systemic vascular resistance.

TAPVC physiology(13) can be further explained based on the presence or absence of pulmonary venous obstruction.

TAPVC WITHOUT PULMONARY VENOUS OBSTRUCTION:

- At birth, there is an equal distribution of blood to the pulmonary and systemic circulation because of almost equal pulmonary vascular and systemic vascular resistance.
- In the first few weeks of the neonatal period, there is a fall in pulmonary vascular resistance, and an increased amount of mixed blood goes to the pulmonary circulation.
- Thus, there is a progressive RV and Pulmonary artery dilatation with infants having systemic or supra systemic pulmonary arterial pressure.
- There is only a slight elevation in pulmonary arterial pressures in a few patients who grow with TAPVC to adulthood.
- However, there is medial hypertrophy and intimal hyperplasia, reversing severe, irreversible pulmonary arterial hypertension in the 3rd -4th decade of life.

TAPVC WITH PULMONARY VENOUS OBSTRUCTION:

- Elevated pulmonary venous pressure leads to pulmonary edema and an increase in right ventricle afterload with the left shift of interventricular septum. This leftward shift can clinically manifest as a low cardiac output state.

CLINICAL MANIFESTATIONS(8)

The signs and symptoms in TAPVC are variable, depending upon the variable hemodynamics, the adequacy of mixing at interatrial level and presence or absence of pulmonary venous obstruction.

CLINICAL FEATURES

TAPVC WITHOUT PULMONARY VENOUS OBSTRUCTION	TAPVC WITH PULMONARY VENOUS OBSTRUCTION
• Asymptomatic at birth	Symptomatic at birth.
• Feature of pulmonary over circulation Present.	Features of pulmonary venous
• Mild cyanosis present.	Cyanosis at birth
• Gradual development of right heart failure And pulmonary arterial hypertension.	Rapid progression of RV failure with age at death ranged from 2 days to 5 month.
ECG FEATURES:	
• Tall p waves in lead II or right precordial Leads suggestive of RA enlargement.	Features of right ventricular hypertrophy. Features of RA enlargement are absent.
• Right axis deviation.	
• Incomplete RBBB.	
RADIOLOGICAL FEATURES:	
• RA/RV enlargement with dilated Pulmonary artery.	Ground glass appearance without Cardiomegaly.
• Figure of eight or snowman appearance	

CARDIOPULMONARY BYPASS TECHNIQUES(9):

During initial days of TAPVC repair, severe hypothermia with or without total circulatory arrest was frequently used. However, now being aware of the ill effects of deep hypothermia and complete circulatory arrest on the postoperative outcomes, surgeries are done on moderate hypothermia with low flows if needed.

SURGICAL TECHNIQUE(9)

- Muller was the first to attempt surgical correction in 1951 by anastomosing the common pulmonary vein to the left atrium.
- In 1956, Burroughs and Kirklin reported the “atrial well” technique.
- In 1956, Lewis successfully corrected a TAPVC in a 5-year-old child by using hypothermia(14).
- Cooley and Ochsner performed the first successful repair using a cardiopulmonary bypass in 1957.

The repair is currently performed on cardiopulmonary bypass using bicaval cannulation and moderate hypothermia or, in some cases, deep hypothermic circulatory arrest. The negative long term effect of prolonged DHCA has already been stated (Belliner et al.)(15).
TAPVC surgical management has undergone many changes, from perfusion techniques to myocardial protection strategies and surgical management.

SURGICAL TECHNIQUE:

Midline sternotomy is performed, and ductus arteriosus is dissected. The patient is heparinized, and purse strings are taken over the aorta, SVC and, IVC. Cannulation is completed, and bypass is initiated.PDA, if present, is ligated at this point. Most of the TAPVC surgeries are performed under moderate hypothermia in our unit, and profound

hypothermia is used for complex anatomies or sometimes infracardiac TAPVC. During cooling, the main pulmonary artery is vented, and the same site is used later for PA catheter insertion(if needed).After cooling to the required temperature

In our unit, we ligate the vertical vein. The approach adopted further depends upon the type of TAPVC and the pulmonary venous drainage.

POSTERIOR APPROACH:

This approach was first described by William et al (1964)(16). The apex of heart is elevated out of the pericardial well and tilted towards the right side to give exposure to the posterior left atrium along with the pulmonary venous confluence.

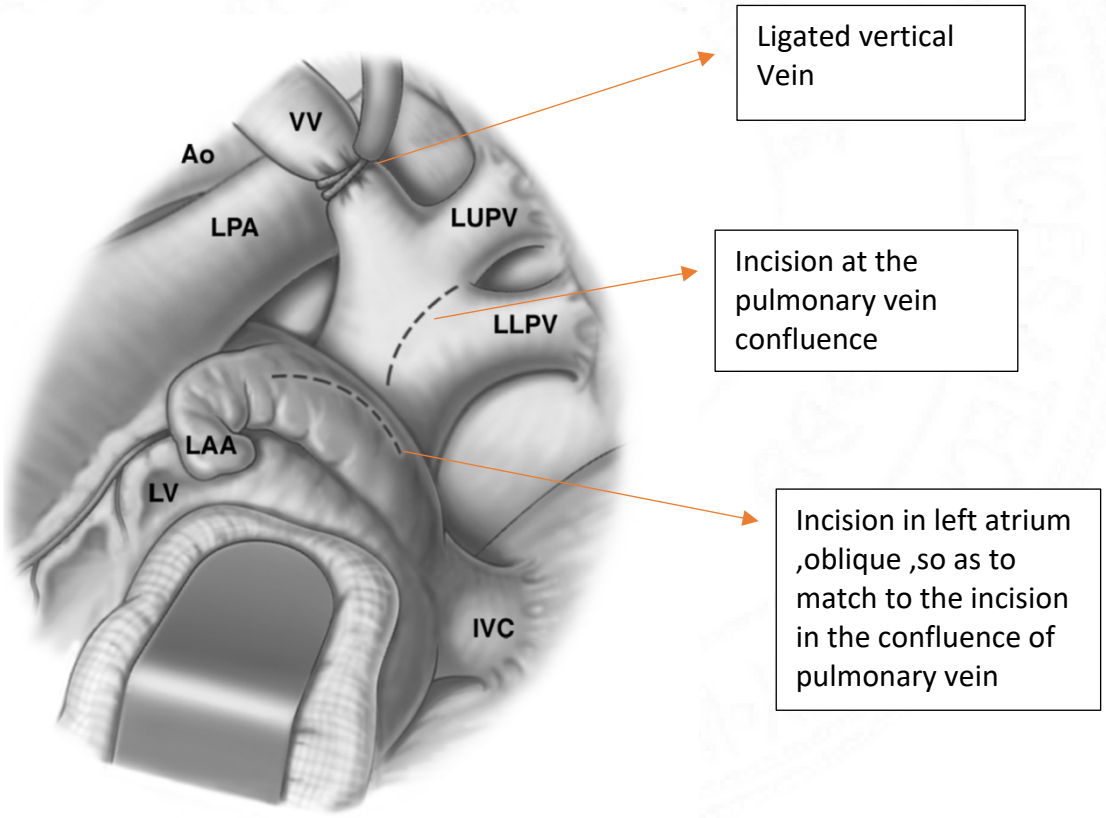
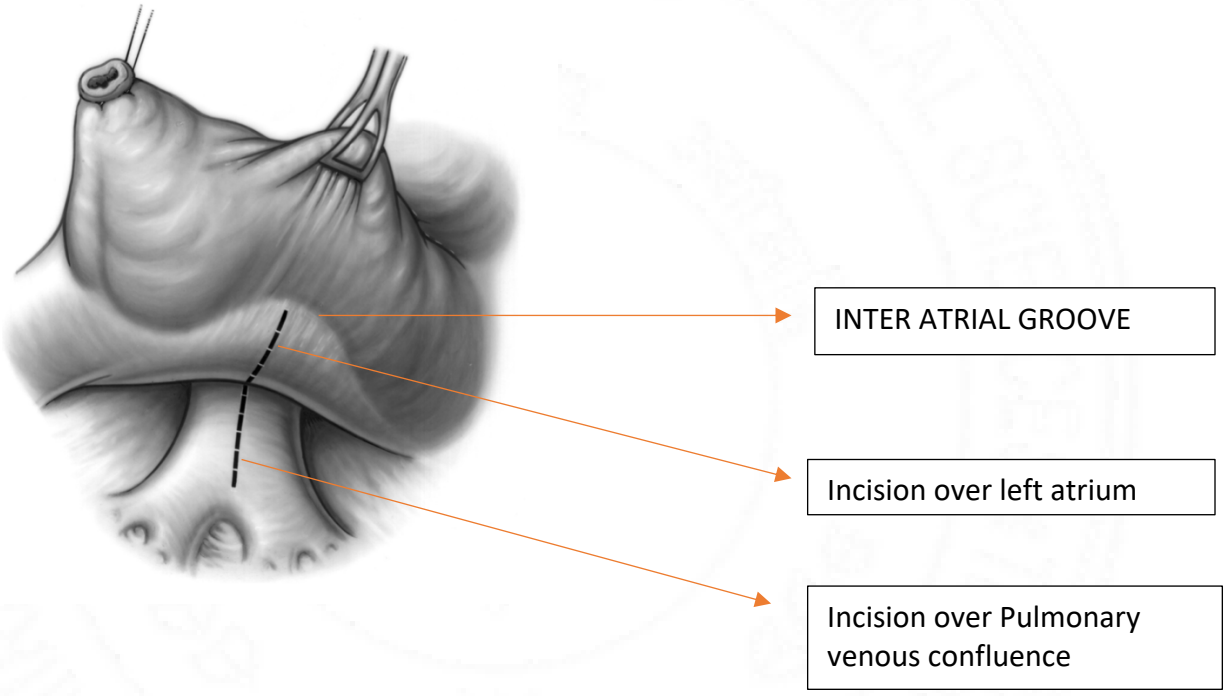


FIGURE 10

The anastomosis between the left atrium and pulmonary venous confluence should be as large as possible to decrease the risk of stenosis at the site of anastomosis itself.

RIGHT LATERAL APPROACH:

In this approach the confluence of pulmonary vein is dissected free from the right and left atria.The left atrium is opened behind the sondergaard`s groove in a vertical fashion ,oriented to the incision given on the pulmonary venous confluence and both are hence anastomosed with prolene sutures.



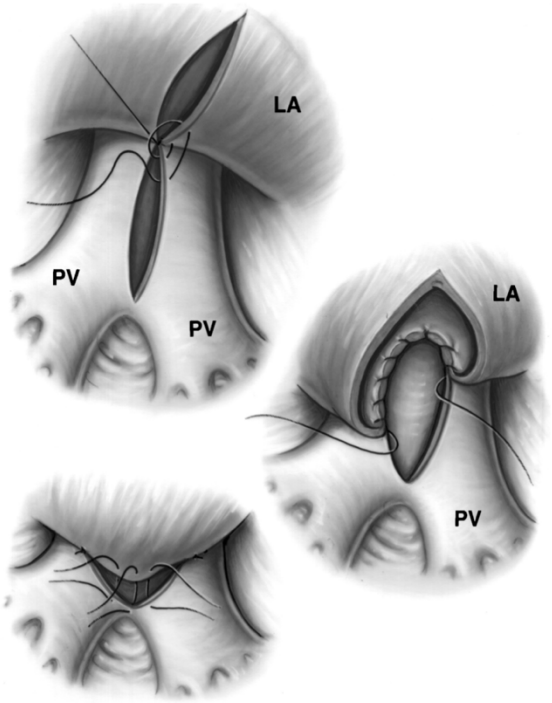


FIGURE 11

SUPERIOR APPROACH:

As first described by Tucker et al (17),this approach is suited to patients with supracardiac TAPVC where pulmonary venous confluence drains to SVC-RA junction.

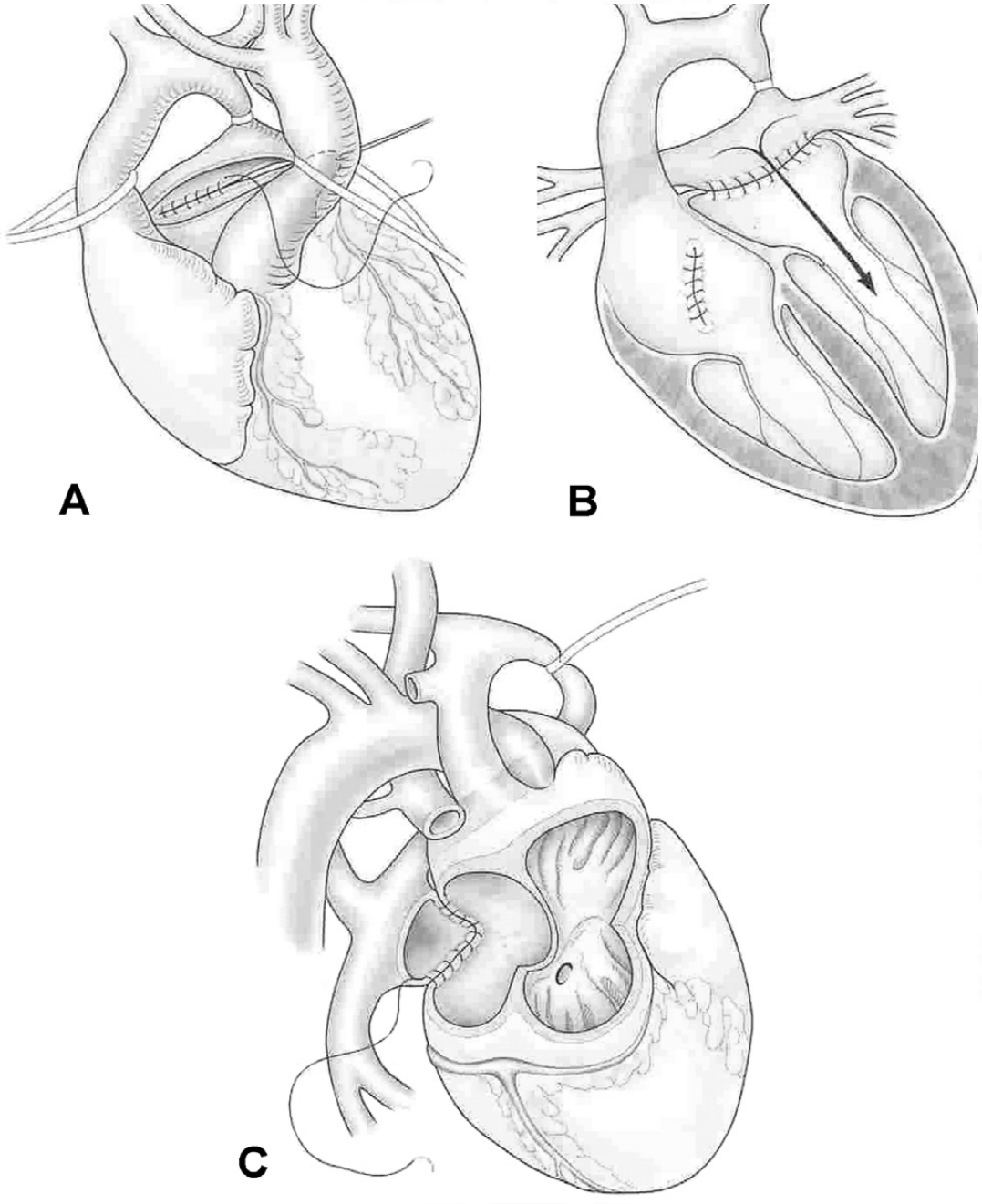


FIGURE 12

BIATRIAL APPROACH:

As suggested by Schumacher and King (1961)(18),the incision in this approach is directed towards the interatrial groove.The incision is then continued posteriorly across the interatrial septum into the left atrium.

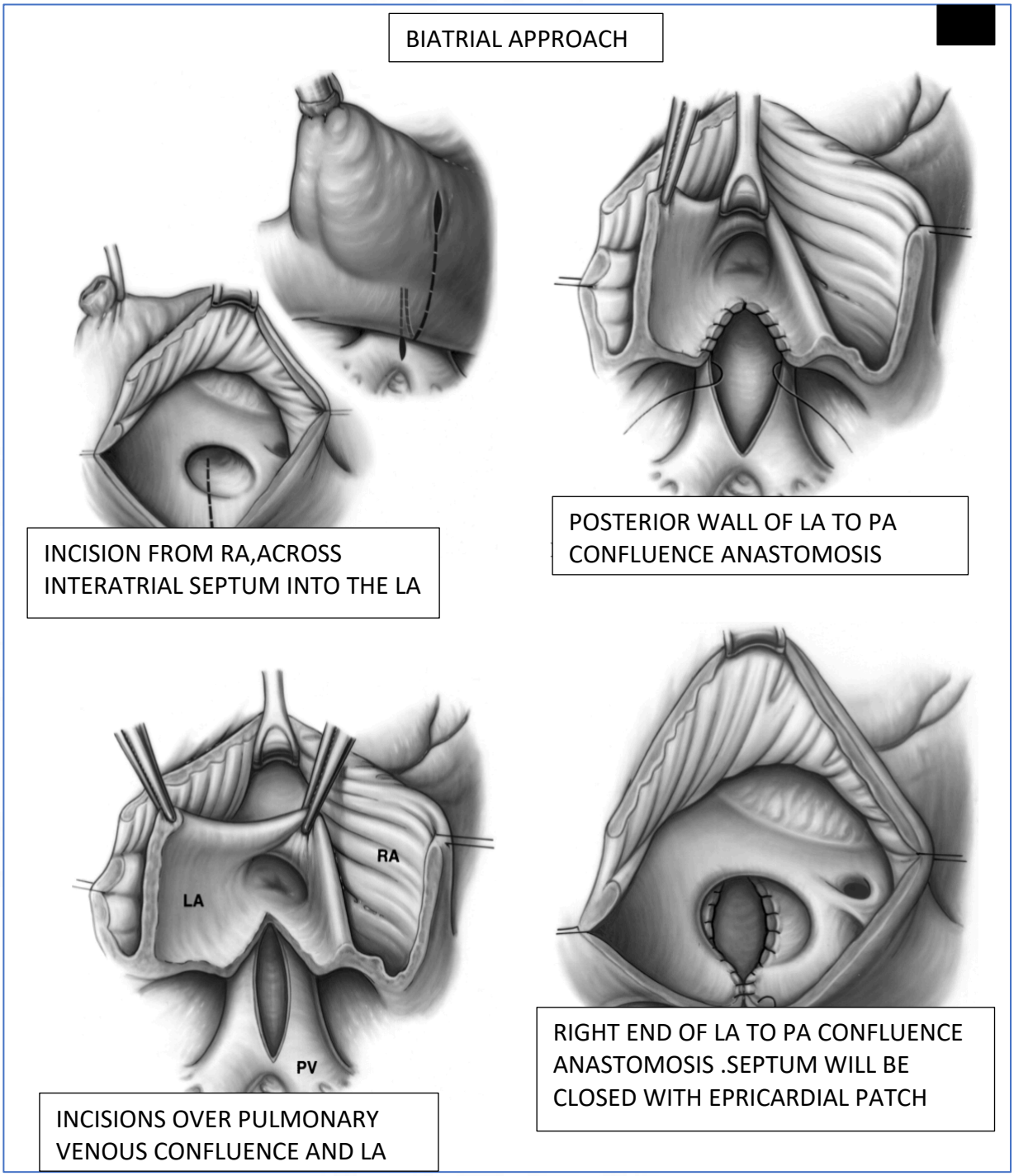


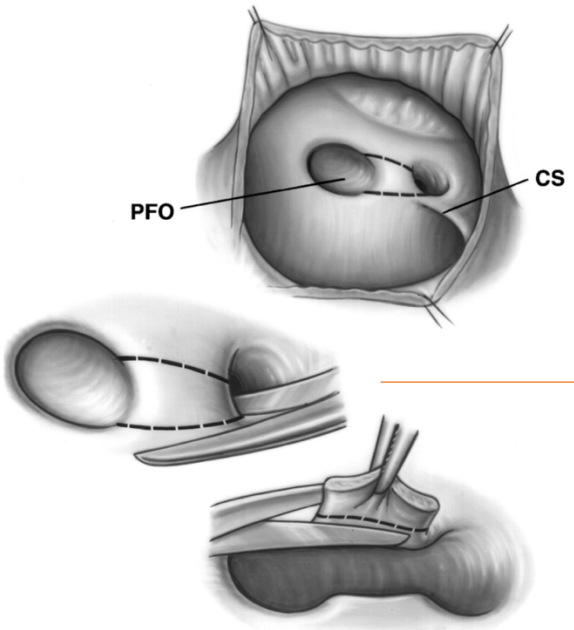
FIGURE 13

CARDIAC TYPE TAPVC:

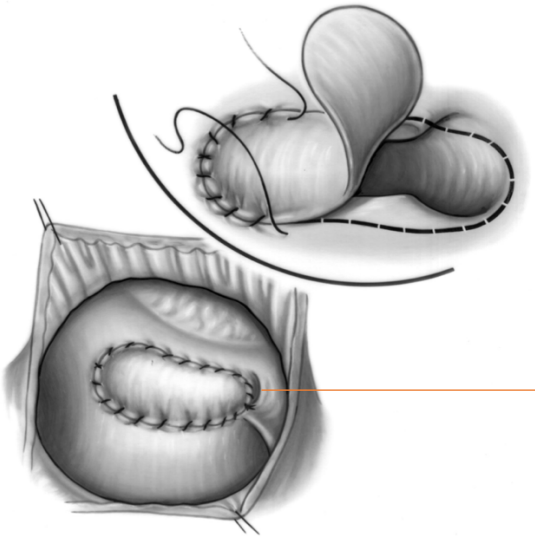
As previously mentioned in the classifications, cardiac type TAPVC can have pulmonary veins draining directly into the right atrium or into the coronary sinus.

Principle behind correction-create asd large enough that will accept all pulmonary venous drainage without any obstruction. Then a patch is sutured around the defect and around the pulmonary veins orifice ,thus allowing unobstructed drainage of pulmonary veins.

If pulmonary veins drain into the coronary sinus, we use **coronary sinus cutback technique(19)**.



Incision is made from roof of coronary sinus into the foramen ovale.



Autologous pericardium sutured in place.

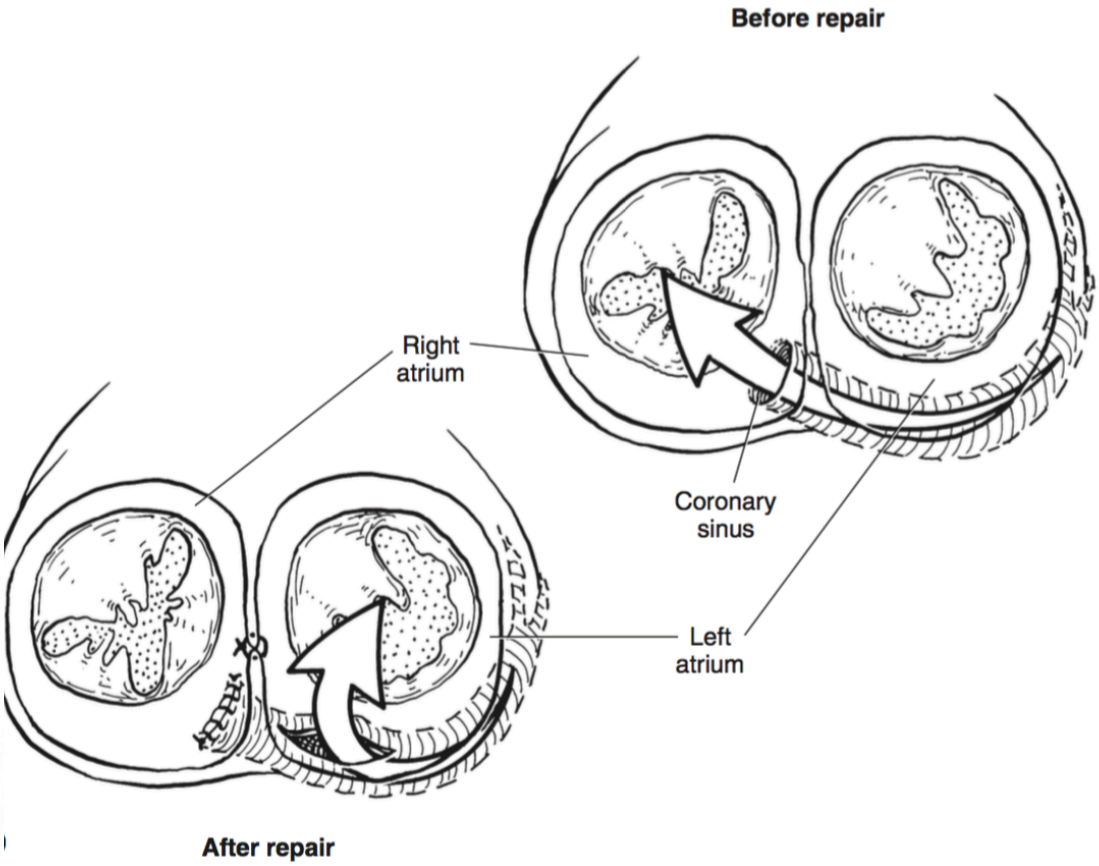

Before repair
Right atrium
Coronary sinus
Left atrium
After repair

FIGURE 14

VAN PRAAGH TECHNIQUE- An alternative to coronary sinus cut back technique,this requires an incision into fossa ovalis (a),roof of the coronary sinus is opened up to allow unrestricted pulmonary venous drainage to LA (b).The orifice of coronary sinus to RA and fossa ovalis are closed with direct suture(20).

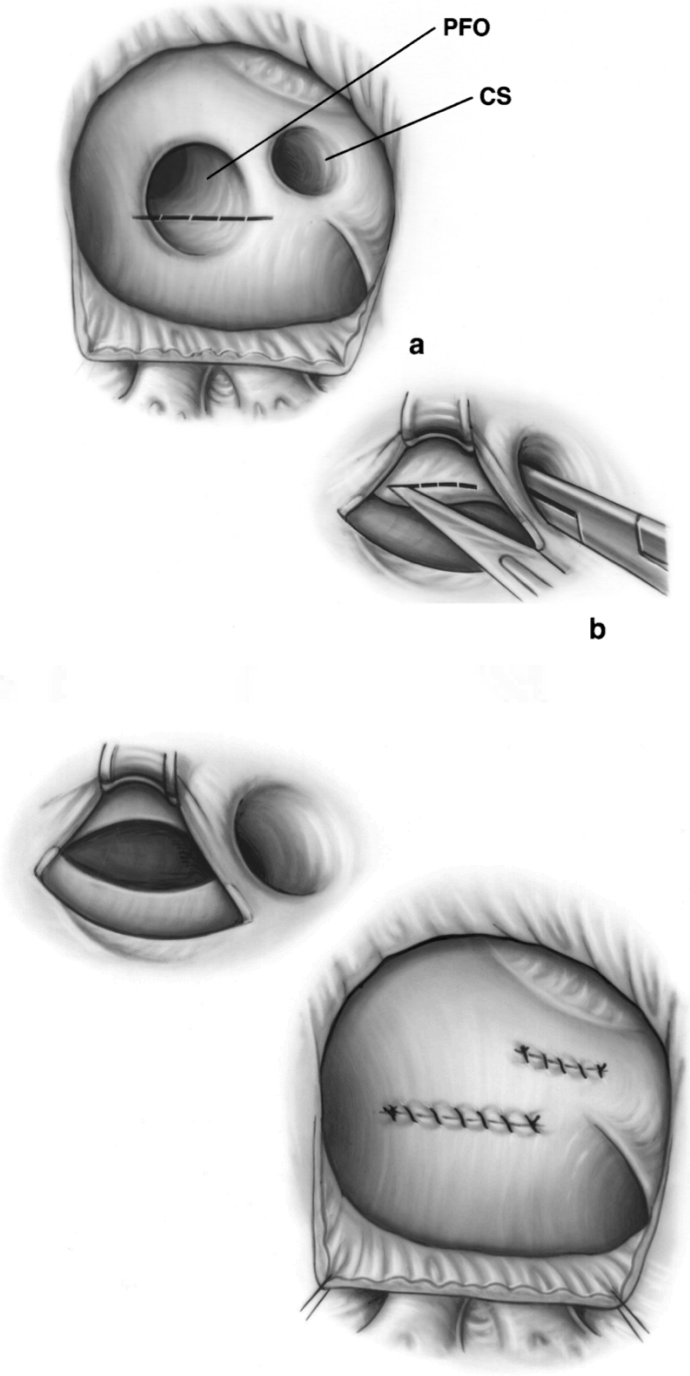


FIGURE 15

INFRACARDIAC TAPVC:

Most of these patients present in the first few days of life with obstructed pulmonary venous flow and are quite moribund at the time of admission.

Posterior approach is used for this type of TAPVC .After going on CPB and arresting the heart,the configuration of pulmonary venous confluence is assessed.Mostly its tree like in appearance and the longest part of the confluence is oriented vertically.Therefore the incision recommended on the pulmonary confluence is vertical and corresponding incision on the atrium should match this incision.LA to pulmonary venous anastomosis is done in routine fashion with ligation of descending vein.

Image:

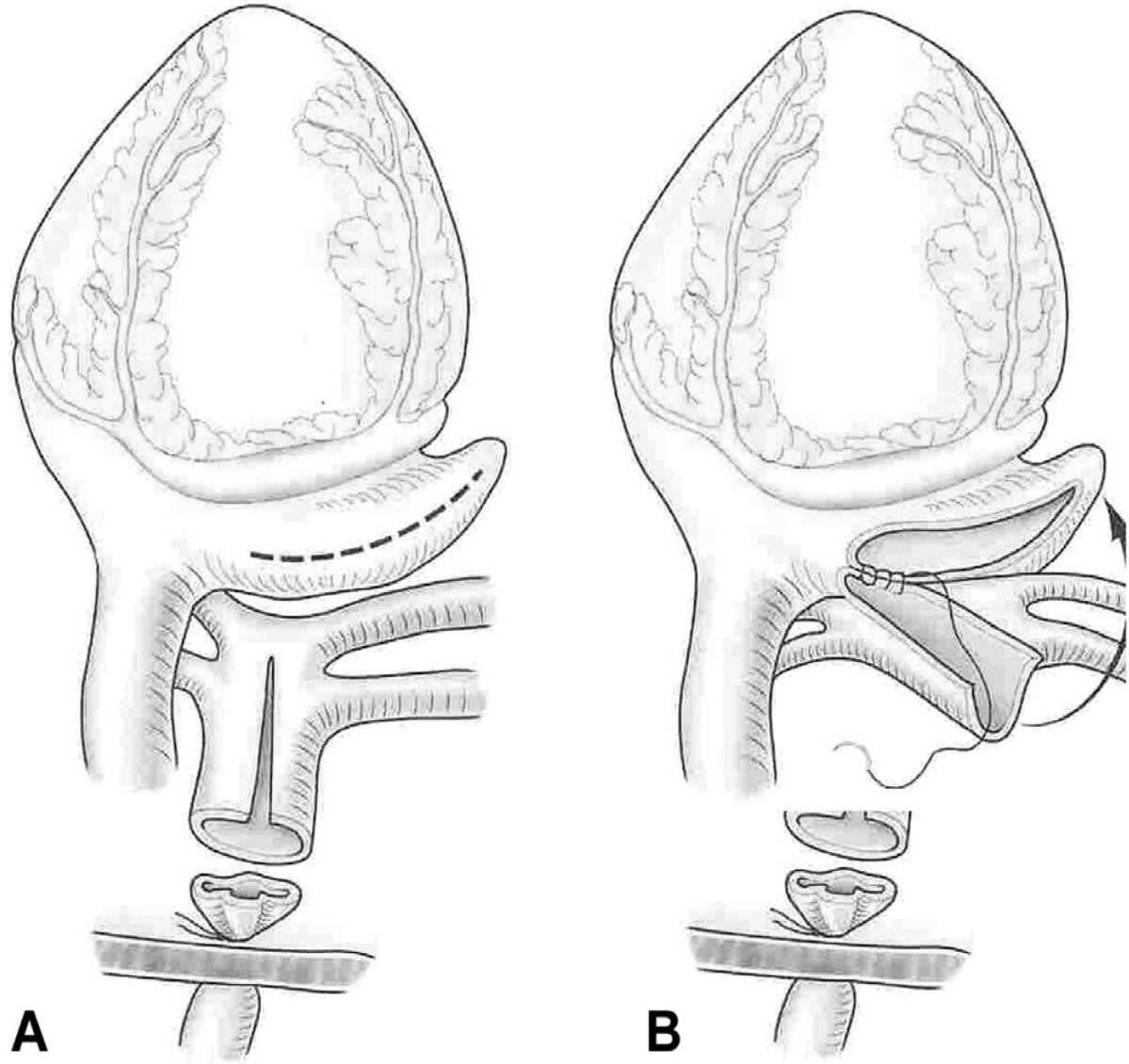


FIGURE 16

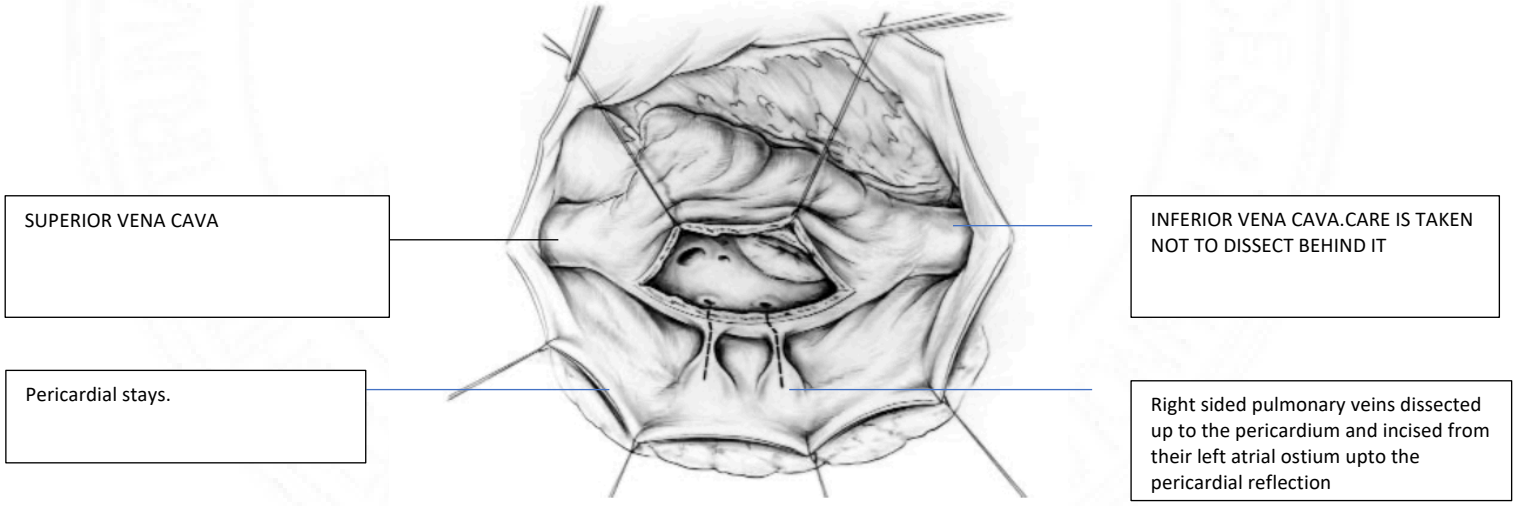
MIXED TAPVC:

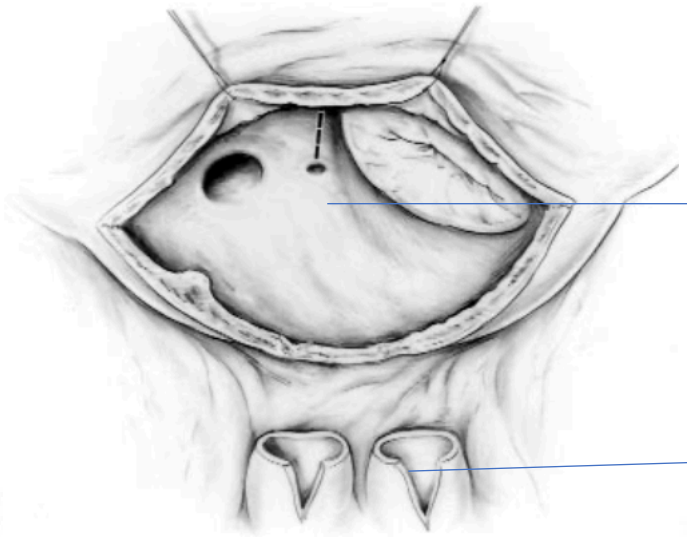
Repair depends upon the exact anatomy .Therefore multiple approaches can be utilized after assessing the pulmonary venous drainage.

PFO is left open in cases of obstructed TAPVC for decompression of the right heart . Rewarming is started and the aortic root is kept on vent. Once fully rewarmed, aortic clamp is removed and PA vent is off .Gradually the process of deairing and decannulation is performed in routine way. After bypass, modified ultrafiltration is performed and PA line is inserted for post operative PA pressure monitoring.

PRIMARY SUTURLESS TECHNIQUE(21):

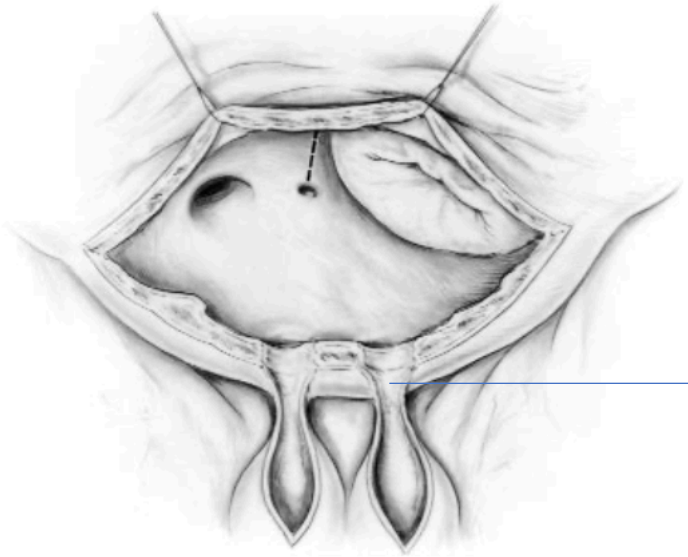
Two major causes of mortality after TAPVC repair are pulmonary hypertension and pulmonary venous obstruction. Atriopericardial or suturless repair has been used previously for recurrent pulmonary venous stenosis.



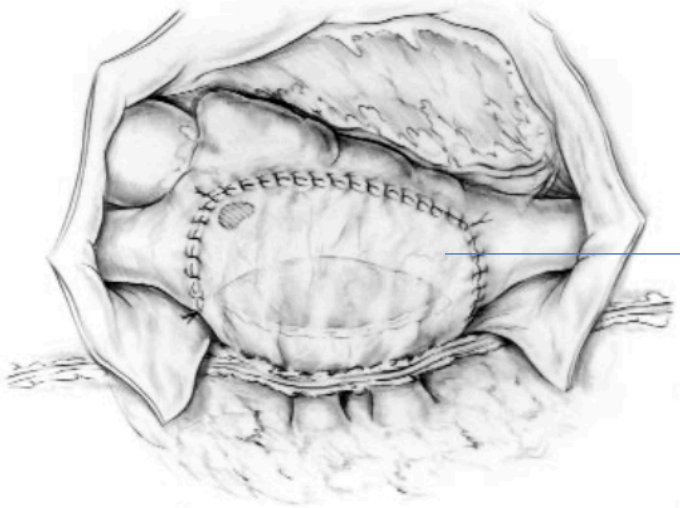


Left sided pulmonary vein incised superiorly towards the posterior pericardial cavity maintained seal by adhesion

Right sided pulmonary vein pathologic tissue is totally resected with part of left atrial wall.



Right sided pulmonary veins are unroofed

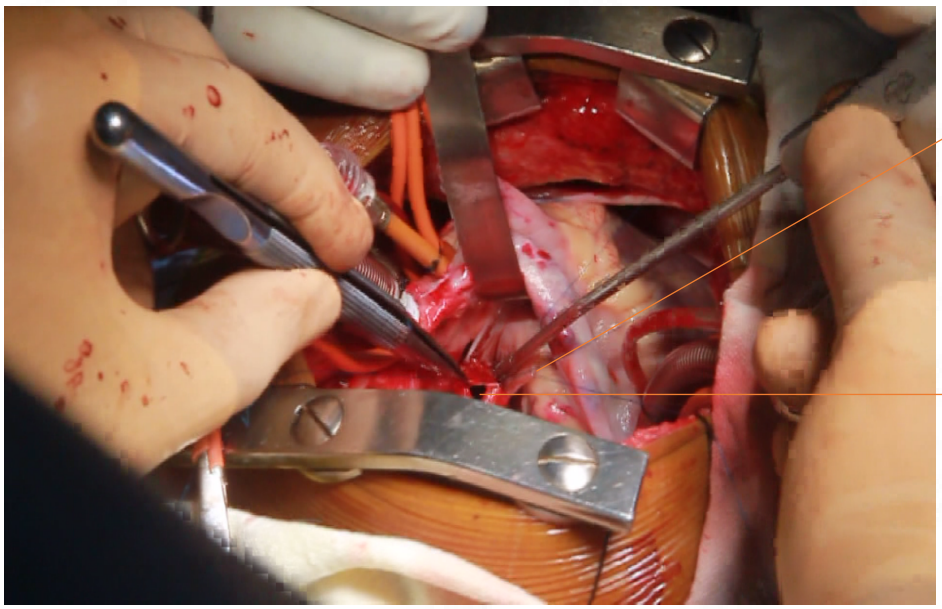


Flap of native pericardium is anastomosed to the right atrial wall,thus creating a pouch of insitu pericardium ,draining the right sided pulmonary veins into left atrium.

FIGURE 17

As seen in the above illustrations,there are no suture lines in native pulmonary vein tissue.Therefore this technique is also referred to as “suturless”.Potential advantage with this technique is limited reactive intimal proliferation and lesser distortion of pulmonary veins,therefore supposedly lesser chance of pulmonary vein stenosis in post operative period.

MODIFIED CLOSED CHAMBER SUTURELESS TECHNIQUE:



LA APPENDAGE ANASTOMOSED TO COMMON CHAMBER

COMMON CHAMBER

FIGURE 18

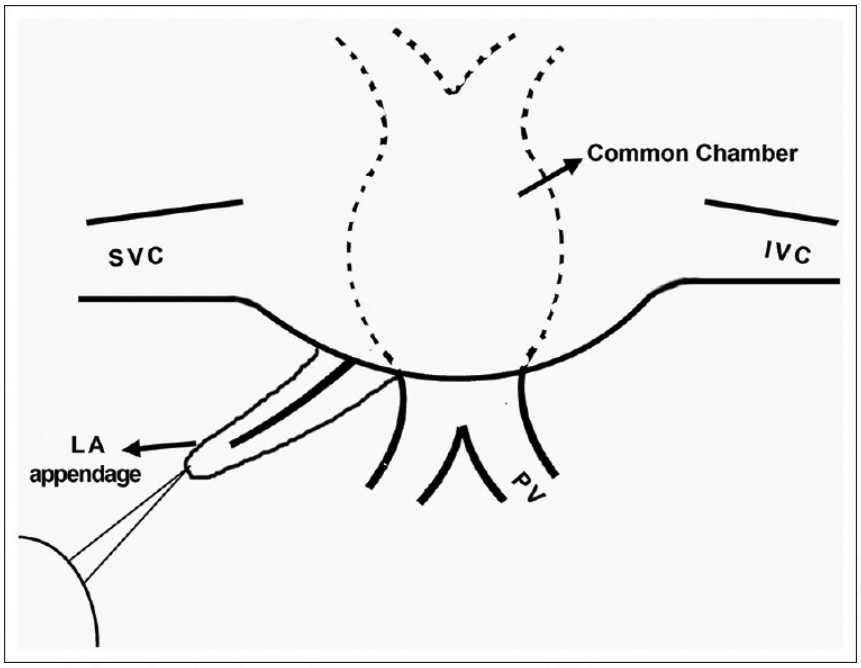


FIGURE 19

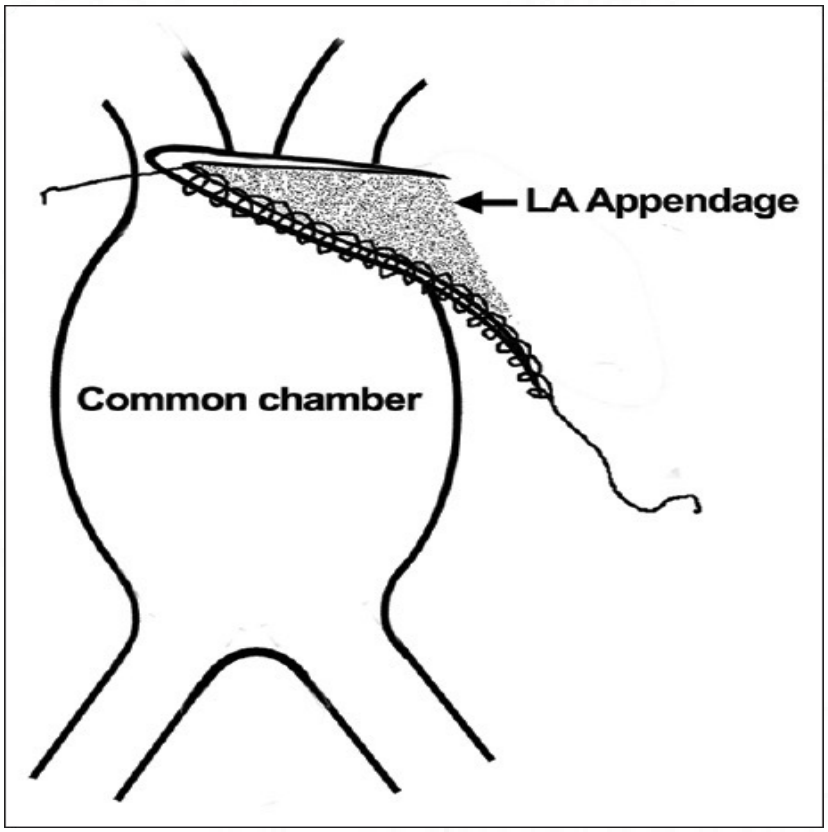


FIGURE 20

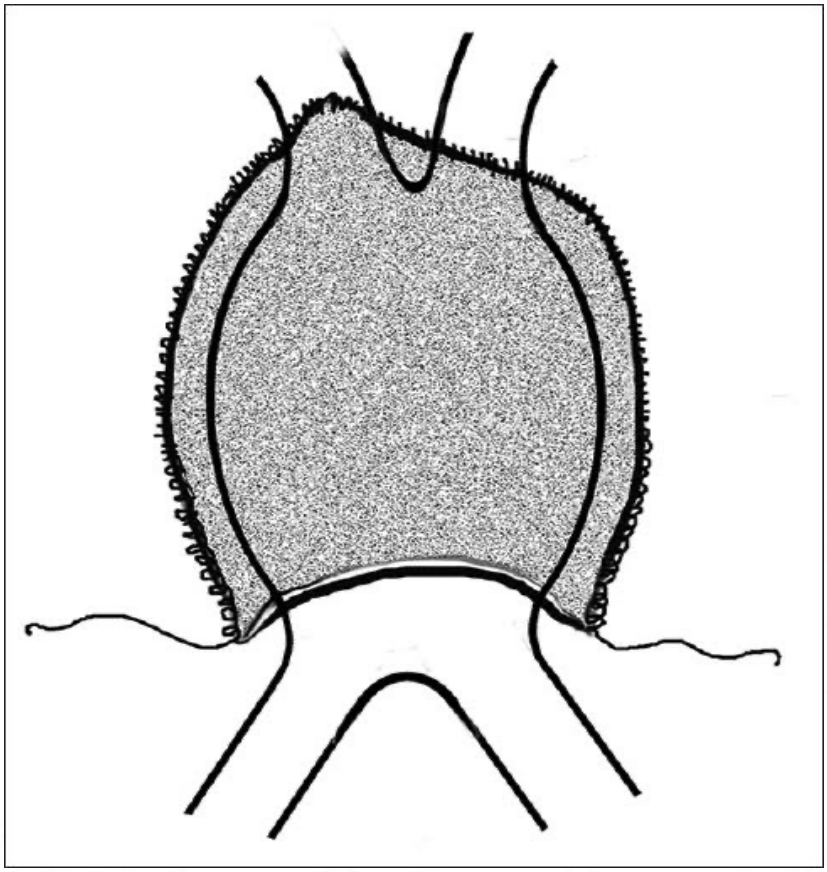


FIGURE 21

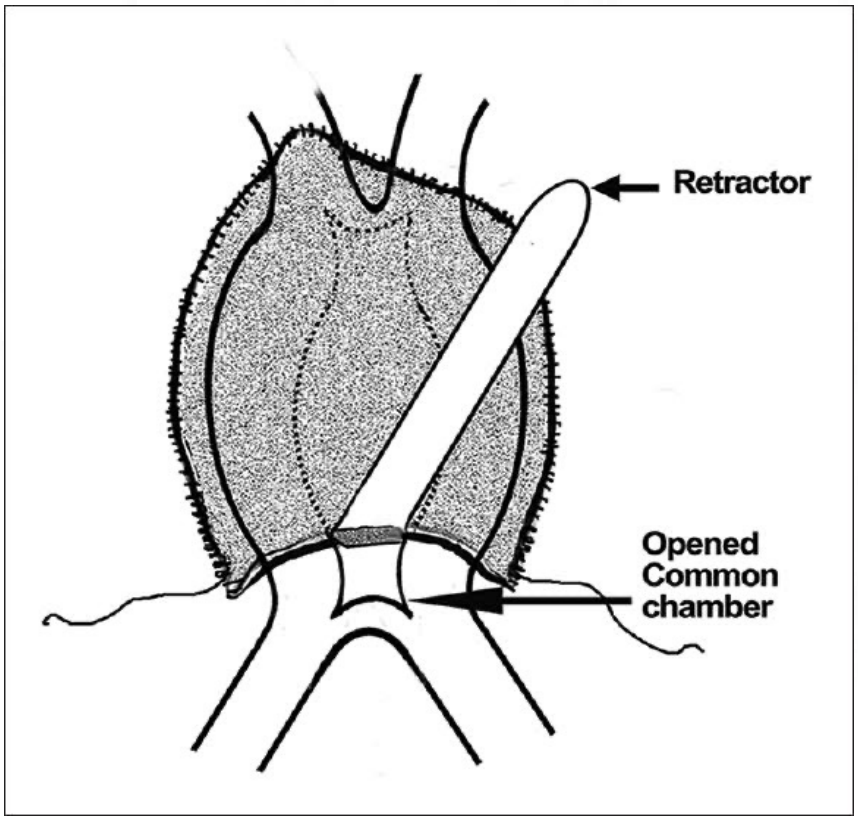


FIGURE 22

POST OPERATIVE CARE:

POST OPERATIVE PHYSIOLOGY:

• Pulmonary vasculature has a thickened medial layer
• PVR does not decrease normally after repair
• RV has to pump against an increased after load
• LV is unable to support the circulation
• under filled and underutilized prior to correction.
• Function is hampered by septal displacement.
• Postoperative period is complicated by *existence of a low output state, persistence of pulmonary hypertension and a highly reactive pulmonary vasculature*

POSTOPERATIVE MANAGEMENT:

• Early postoperative echo to assess PV gradients and RV pressures
• Use of transthoracic PA or LA lines
• Delayed sternal closure has been shown to help tide over the immediate post-pump situation with myocardial edema and alveolar lung trauma.
• Supraventricular arrhythmias are common after TAPVC repair (5–10%, with a higher incidence in cardiac TAPVC)

• Pulmonary hypertensive crises
• Can be suspected in the event of unexplained tachycardia, high CVP, hypotension, and desaturation
• Ventilatory strategy chosen to minimize PA pressures
• Vt of 10–12 cc/kg and normocarbia or mild respiratory alkalosis.
• **iNitric oxide**
• Rapidly diffuses through the alveolar capillary membrane and activates soluble GC leading to smooth muscle relaxation.
• Effective in reducing PVR despite the post CPB endothelial injury
• Typical doses vary from 5-80 ppm.

• Rapid inactivation by hemoglobin, no systemic hypotension and consistent effect in decreasing PAP

COMPLICATIONS:

ARRHYTHMIA:

• Resting ECG is usually normal on 24- hour monitoring
• SVT, bradyarrhythmia, and multiform supraventricular and ventricular ectopic beats have been described.
• High incidence of sinus note dysfunction

PULMONARY VEIN STENOSIS:

• Incidence 5-18% in large series(22)
• Etiology unclear
• Reaction of tissues either to the operation or to prosthetic material
• Unrelieved obstruction upstream to the pulmonary venous pathway(Especially in cardiac type)
• Surgical error, such as the construction of small anastomosis, inadequate unroofing of the CS
• Intimal proliferation from the flow disturbance
• Pre-operative predisposing factors include hypoplasia of the pulmonary veins, the extension of muscle from intrapulmonary to extrapulmonary veins, thickening of the PVs wall
• Readmission 4 to 6 weeks after the operation with pulmonary edema.
• More common in patients with a small PV confluence and postoperative pulmonary HTN
• Reoperation carries a high mortality and a strong chance of recurrence
• Poor outcome with repair if all veins involved and PA pressure high
• Doppler interrogation will demonstrate a small anastomosis and/or a continuous, non-phasic relatively high-velocity doppler flow signal and an enlarged right ventricle(11)
• Catheterization reserved for patients where
• site of obstruction cannot be identified
• clinical course and echocardiographic findings do not match

• placement of stents

CMRI or CT useful to clarify questionable echocardiography findings

AIMS AND OBJECTIVES

AIM OF THE STUDY-

To retrospectively analyse the outcomes after isolated TAPVC repair.

OBJECTIVES-

- To assess outcome of TAPVC repair.

- Risk factors having impact on the early post operative period and on long term survival .

- To compare various surgical techniques used and respective postoperative outcomes.

- To evaluate the number of re-interventions and the cause for re-interventions.

MATERIALS AND METHODS

The present study was conducted in the Department of Cardiovascular and Thoracic Surgery, Sree Chitra Tirunal Institute of Medical Sciences and Technology, Thiruvananthapuram. This study was conducted in a period from 1st January 2008 to 31st December 2018. The study was approved by the institute research and ethics committee. All Data was collected from the hospital database.

STUDY TYPE: A retrospective single Centre observational study

This is a single-center retrospective observational study. A retrospective review of the patient's medical records, including in-hospital and outpatient records, laboratory data, echocardiography, electrocardiogram (ECG), or other non-invasive images, was performed. All patients with isolated TAPVC (as per the inclusion criteria) were included in the study. Patients not having sufficient records available on the database were contacted through telephone and were asked to attend the outpatient clinic for follow up only if they gave their consent.

STUDY PERIOD: 1ST JANUARY 2008 TO 31ST DECEMBER 2018

Participants: A total of 242 patients who underwent correction for isolated TAPVC between 1st January 2008 to 31st December 2018 were included. Associated anomalies were Atrial Septal Defect (ASD) or patent ductus arteriosus (PDA) in most of these cases (part of isolated TAPVCs). Other forms of TAPVC (associated with heterotaxy or other complex cardiac defects) were excluded from this study.

Inclusion criteria:

All patients diagnosed as isolated TAPVC (isolated or simple TAPVC was diagnosed if the patient had TAPVC in association with an ASD or PDA or both) and underwent surgical repair in SCTIMST during the period of 01/01/2008 to 31/12/2018.

Exclusion Criteria:

1. Patients with associated complex cardiac anomalies along with TAPVC.
2. Patients with univentricular anatomy or heterotaxy.
3. Patients lost to follow up.

Approval from the Technical Advisory Committee: Taken before commencing the study.
Funding: Not required

The patient cohort was further divided into subgroups based on various preoperative, intraoperative, and postoperative variables. An excel sheet was prepared for data entry and patient variables like age, weight, preoperative echo parameters, type of TAPVC, obstructed or unobstructed pulmonary venous drainage, the severity of pulmonary arterial hypertension and pulmonary vein score, postoperative ICU stay in days, Vasoactive inotropic score were all recorded. Patients were divided according to Darling's classification into Supracardiac, Cardiac, infracardiac, and mixed types. Obstructed and unobstructed types were decided by clinical presentation, oximetry, and preoperative transthoracic echocardiogram. Pulmonary arterial hypertension was classified based on echo derived parameter (RV systolic pressure + RA pressure) into mild (20-40 mm Hg), moderate (>40 -60 mm Hg), and severe (>60 mm Hg).

Intraoperative variables:

1. The Ph before instituting Cardiopulmonary bypass-This variable was added to the study to hypothesize that patients with severely acidotic Ph before the surgery have prolonged ICU stay with morbid postoperative phase.
2. Clamp time, bypass time(min)(Cardiopulmonary bypass variables)
3. Temperature -Over time, the strategies of myocardial protection have changed. Earlier patients were operated on deep hypothermia (temperature 15-22 °C)or circulatory arrest. However, with evolving techniques, now most of the patients are being operated with mild to moderate hypothermia(mild being 30-34°C and moderate being 25-30°C) with low flows if required.
4. Type of surgery performed.
5. Post pump pulmonary arterial pressures

SURGICAL TECHNIQUE:

Various conventional surgical techniques have been used in TAPVC correction. Depending upon the type of TAPVC, they can be:

- POSTERIOR APPROACH
- RIGHT LATERAL APPROACH
- CORONARY SINUS CUTBACK TECHNIQUE
- VAN PRAAGH TECHNIQUE
- SCHUMACHER KING

Initially, the common chamber/pulmonary veins used to be directly anastomosed to the left atrium. At our center, we do the **primary sutureless technique(21)**, where the anastomosis is between the posterior pericardium and the left atrium.

Postoperative vasoactive inotropic score after 24 hours of ICU admission was noted and compared.

INOTROPIC SCORE(IS)= Dopamine dose(mcg/kg/min)+ Dobutamine dose (mcg/kg/min) + 100 x Epinephrine dose(mcg/kg/min)

VASOACTIVE INOTROPIC SCORE(VIS)(23)= IS+ 10 x Milrinone (mcg/kg/min) + 10000 x Vasopressin dose (units/kg/min) + 100 x Norepinephrine dose (mcg/kg/min)

The number of ICU days, any instance of Pulmonary arterial crisis, postoperative arrhythmias and types, pulmonary hemorrhage(based on raised airway pressures on a ventilator or respiratory distress with a chest x-ray to support the evidence) and mortality and its causes were also noted for each patient. Mortality was further divided into early mortality(<30 days of operation) and late mortality.

Any cause for reintervention and 5 year/10 years follow up pulmonary venous flow was recorded from the outpatient echocardiogram reports available on the database.

Patient data were analyzed, and the risk factors for mortality or morbidity were determined.

Outcome Parameters: Evaluation of study objectives.

STATISTICAL ANALYSIS:

Kaplan Meier survival analysis was performed to assess the overall survival rate.
Survival rate was compared across the age group, gender, type, weight, PH, TCA using a log-rank test. Mortality and pulmonary venous flow were considered as primary outcome variables. The type of TAPVC was considered as a Primary explanatory variable. Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency, and proportion for categorical variables. Non normally distributed quantitative variables were summarized by the median and interquartile range (IQR). Data was also represented using appropriate diagrams like a bar diagram, pie diagram, and box plots.
All Quantitative variables were checked for normal distribution within each category of an explanatory variable using visual inspection of histograms and normality Q-Q plots. Shapiro-Wilk test was also conducted to assess normal distribution. Shapiro Wilk test p-value of >0.05 was considered as a normal distribution.
For normally distributed Quantitative parameters, the mean values were compared between study groups using ANOVA (>2 groups). For non-normally-distributed Quantitative parameters, Medians and Interquartile range (IQR) were compared between study groups using the Kruskal Wallis test (> 2 g
roups). For non-normally-distributed, the association between quantitative explanatory and outcome variables was assessed by calculating the Spearman correlation (r_s)coefficient, and the data was represented in a scatter diagram.
Categorical outcomes were compared between study groups using Chi-square test /Fisher's Exact test (If the overall sample size was < 20 or if the expected number in any one of the cells is < 5, Fisher's exact test was used.)P-value < 0.05 was considered statistically significant. IBM SPSS version 22 was used for statistical analysis.

OBSERVATION AND RESULTS

Result:
A total of **242** subjects were included in the final analysis.

Table 1: Descriptive analysis of age group in the study population (N=242)

Age Group	Frequency	Percentages
Neonate	62	25.62%
Infant	157	64.88%
Child	23	9.50%

Figure 23: Bar chart of age group in the study population (N=242)

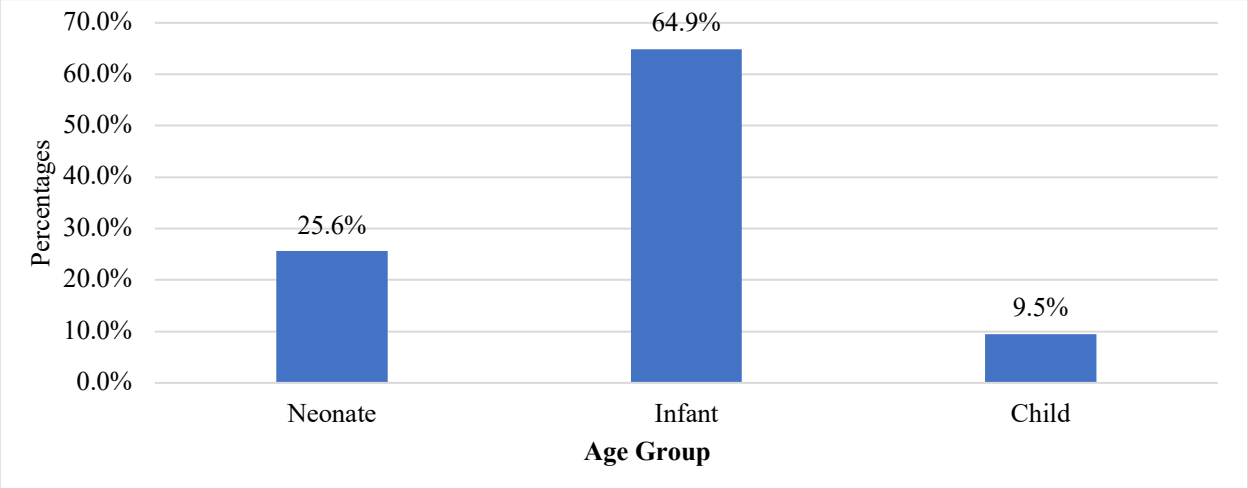


Table 2: Descriptive analysis of gender in the study population (N=242)

Gender	Frequency	Percentages
Male	152	62.81%
Female	90	37.19%

Figure 24: Pie chart of gender in the study population (N=242)

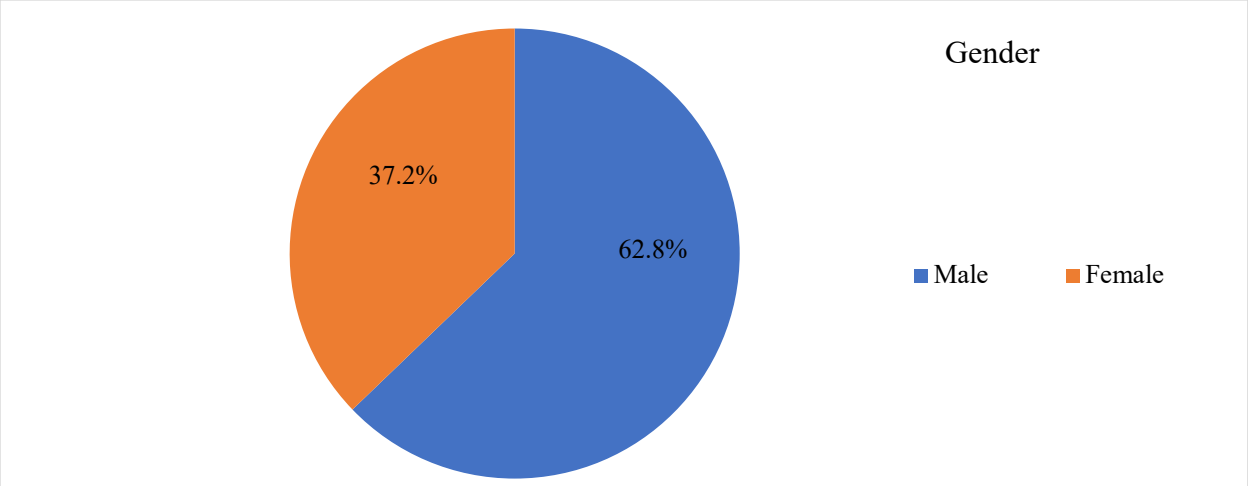


Table 3: Descriptive analysis of weight (in kg) in study population (N=242)

Parameter	Mean ± SD	Minimum	Maximum
Weight (In Kg)	4.57 ± 4.22	1.50	44.00

MEDIAN WEIGHT IN STUDY GROUP : 3.80 Kg

Table 4: Descriptive analysis of Type of TAPVC (obstructed/unobstructed)in the study population (N=242)

Type of TAPVC	Frequency	Percentages
Obstructed	111	45.87%
Unobstructed	131	54.13%

Figure 25: Bar chart of Type of TAPVC in the study population (N=242)

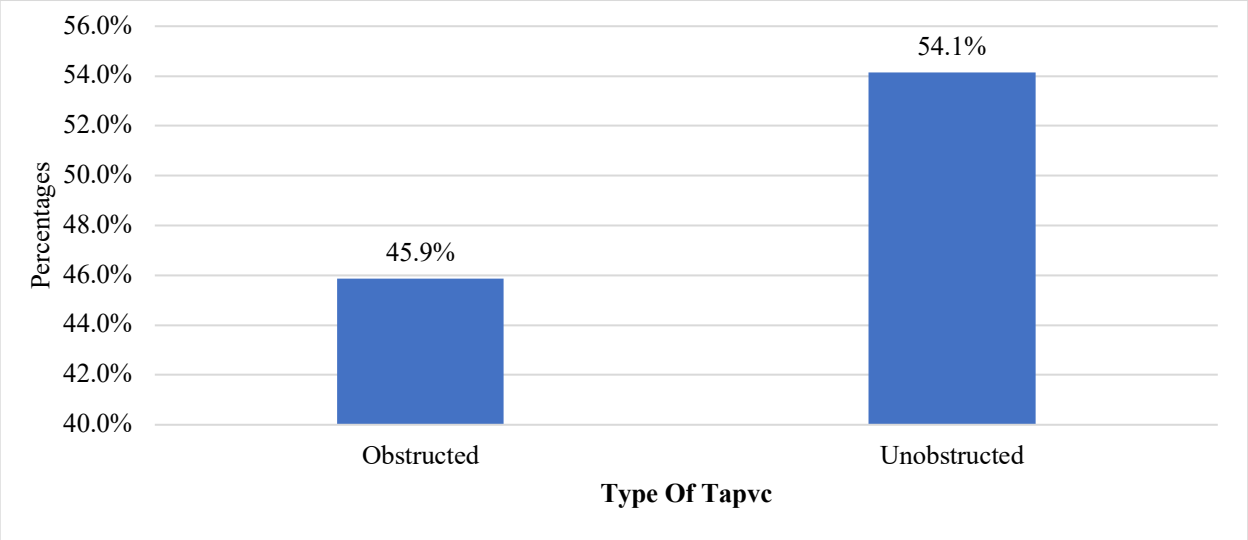


Table 5: Descriptive analysis of type in the study population (N=242)

Type	Frequency	Percentages
Supra cardiac	127	52.54%
CARDIAC	57	23.60%
INFRACARDIAC	35	14.46%
MIXED	23	9.50%

Table 6: Break down of types of TAPVC into obstructed/unobstructed (N=242)

Type	Type Of TAPVC		Chi square	P value
	Obstructed	Unobstructed		
Supra Cardiac (N=127)	47 (37.01%)	80 (62.99%)		
Infra cardiac (N=35)	34 (97.14%)	1 (2.86%)		
Cardiac (N=57)	23 (40.35%)	34 (59.65%)	43.981	<0.001
Mixed (N=23)	7 (30.43%)	16 (69.57%)		

Figure 26: Bar chart of Type of TAPVC in relation to obstruction in the study population (N=242)

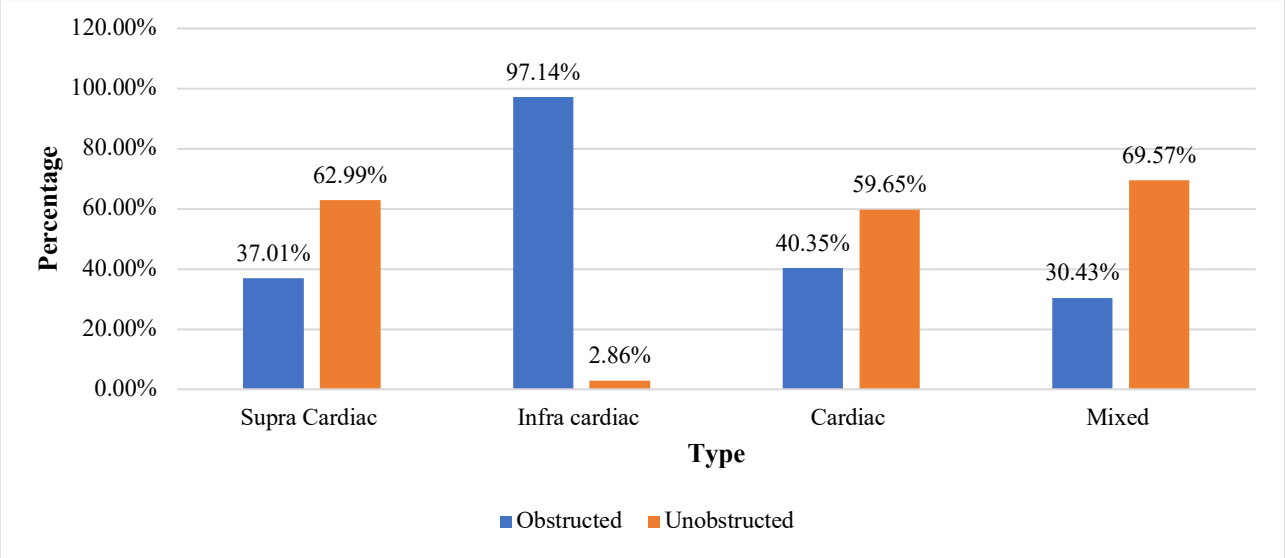


Table 7: Descriptive analysis of PAH in the study population (N=242)

PAH	Frequency	Percentages
None	8	3.31%
Mild	32	13.22%
Moderate	43	17.77%
Severe	159	65.70%

Table 8: Descriptive analysis of PH before CPB (N=242)

Parameter	Mean ± SD	Minimum	Maximum
PH Before CPB	7.37 ± 0.1	6.85	7.73

Table 9: Descriptive analysis of Clamp time (N=242)

Parameter	Mean ± SD	Minimum	Maximum
Clamp Time (N=241)	72.92 ± 26.92	24.00	164.00

Table 10: Descriptive analysis of bypass time (N=242)

Parameter	Mean ± SD	Minimum	Maximum
Bypass Time	131.89 ± 41.73	21.00	256.00

Table 11: Descriptive analysis of type of surgery performed in the study population (N=242)

Surgery	Frequency	Percentages
Sutureless	111	45.87%
Cutback	60	24.79%
Modified Schumaker king	36	14.88%
Posterior approach	35	14.46%

Table 12: Descriptive analysis of PA pressure post-surgery

Parameter	Mean ± SD	Minimum	Maximum
PA Pressure Post Surgery	24.39 ± 8.18	10.0	54.0

Table 13: Descriptive analysis of inotrope score (24 hours post-operative period) (N=242)

Parameter	Mean ± SD	Minimum	Maximum
Inotrope Score (24 Hours)	9.62 ± 8.09	0.00	59.00

Table 14: Descriptive analysis of number of ICU days (N=242)

Parameter	Mean ± SD	Minimum	Maximum
Number of ICU Days	9.09 ± 11.78	0.0	116.0

Table 15: Descriptive analysis of PA crisis in the study population (N=242)

PA Crisis	Frequency	Percentages
Yes	9	3.71%
No	233	96.29%

Table 16: Descriptive analysis of mortality in the study population (N=242)

Mortality	Frequency	Percentages
Yes	20	9%
No	222	91.7%

Table 17: 5 year follow up Pulmonary venous in the study population (N=242)

5 Year Follow Up	Frequency	Percentages
Laminar	231	95.40%
Turbulence	10	4.13%
Obstructed flow	1	0.46%

Table 18: Post-Operative Complications (N=242)

Complications	Frequency	Percentages
Arrhythmias	9	3.7%
Reoperation (Procedure)	7	2.9%
Pulmonary Hemorrhage	1	0.4%

Table 19: Descriptive analysis of weight in the study population (N=242)

Weight (< 3 Kg)	Frequency	Percentages
Yes	50	20.66%
No	192	79.34%

Table 20: Descriptive analysis of pre-operative PH in the study population (N=242)

PH <7.35	Frequency	Percentages
Yes	86	35.54%
No	156	64.46%

Table 21: Descriptive analysis of use of TCA in the study population (N=242)

TCA	Frequency	Percentages
Yes	5	2.07%
No	237	97.93%

Table 22: Comparison of PH <7.35 and ≥7.35 for mortality (N=242)

PH <7.35	Mortality		Chi square	P value
	Yes	No		
Yes (N=86)	10 (11.63%)	76 (88.37%)	1.991	0.158
No (N=156)	10 (6.41%)	146 (93.59%)		

Figure 27: Staked bar chart of comparison of PH <7.35 and ≥7.35 for mortality (N=242)

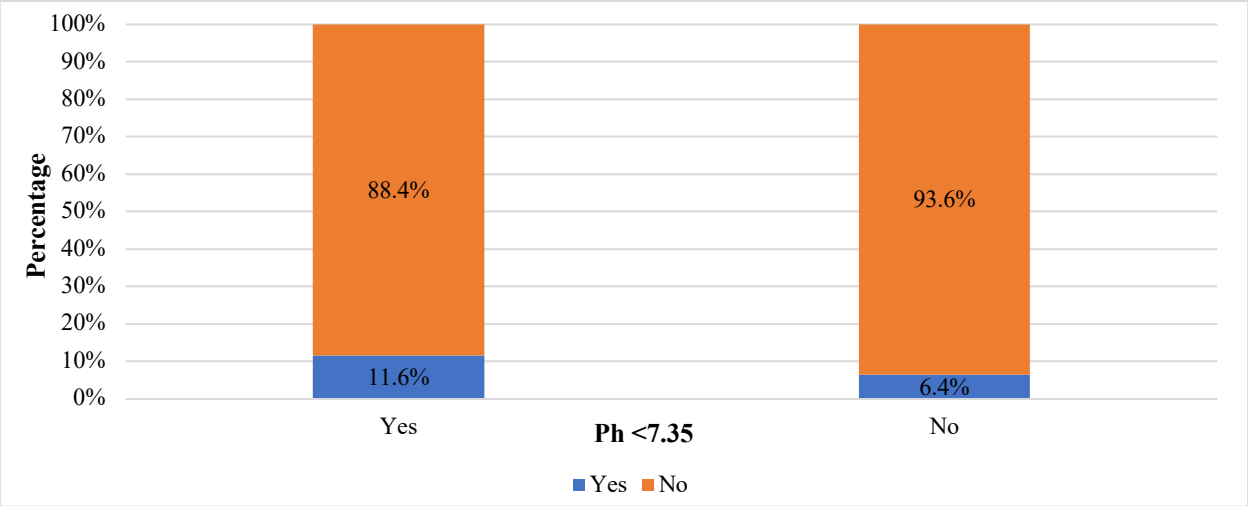


Table 23: Comparison between TCA /Non TCA for mortality (N=242)

TCA	Mortality		Chi square	Fisher exact P value
	Yes	No		
Yes (N=5)	2 (40%)	3 (60%)	6.782	0.056
No (N=237)	18 (7.59%)	219 (92.41%)		

Figure 28: Staked bar chart of comparison of TCA/NON TCA for mortality (N=242)

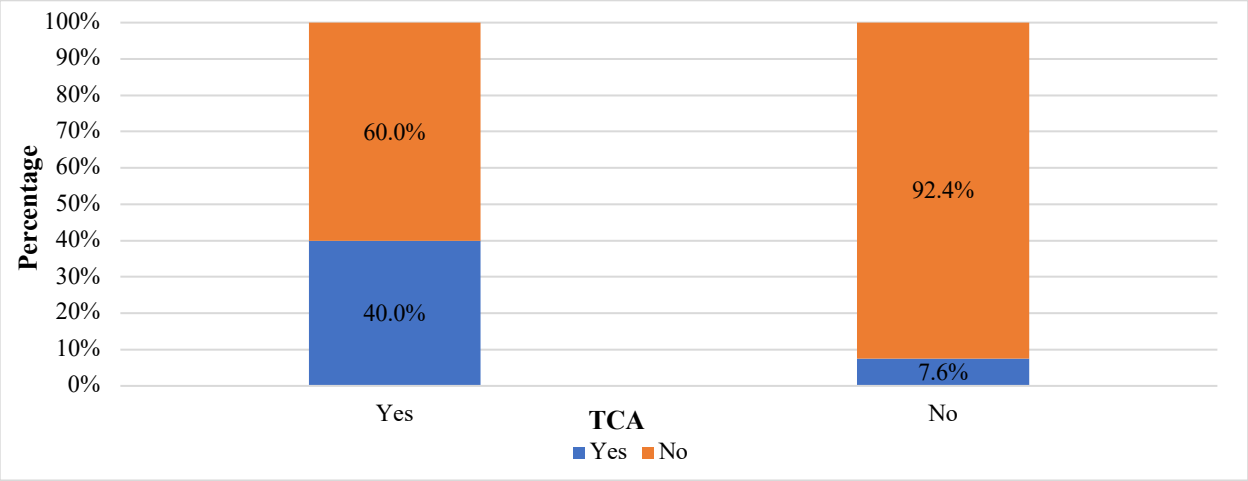


Table 24: Comparison of type of TAPVC(obstructed/unobstructed) and preoperative PAH (N=242)

Type of TAPVC	PAH			
	None	Mild	Moderate	Severe
Obstructed (N=111)	0 (0%)	2 (1.8%)	6 (5.41%)	103 (92.79%)
Unobstructed (N=131)	8 (6.11%)	30 (22.9%)	37 (28.24%)	56 (42.75%)

Table 25: Comparison of type of TAPVC and preoperative PAH (N=242)

Type	PAH			
	None	Mild	Moderate	Severe
Supra Cardiac (N=127)	6 (4.72%)	20 (15.75%)	24 (18.9%)	77 (60.63%)
Cardiac (N=57)	2 (3.51%)	6 (10.53%)	14 (24.56%)	35 (61.4%)
IC (N=35)	0 (0%)	1 (2.86%)	0 (0%)	34 (97.14%)
Mixed (N=23)	0 (0%)	5 (21.74%)	5 (21.74%)	13 (56.52%)

Table 26: Comparison of type of TAPVC for mortality (N=242)

Type of TAPVC	Mortality		Chi square	P value
	Yes	No		
Obstructed (N=111)	17 (15.32%)	94 (84.68%)	13.446	<0.001
Unobstructed (N=131)	3 (2.29%)	128 (97.71%)		

Figure 29: Staked bar chart of comparison of type of TAPVC for mortality (N=242)

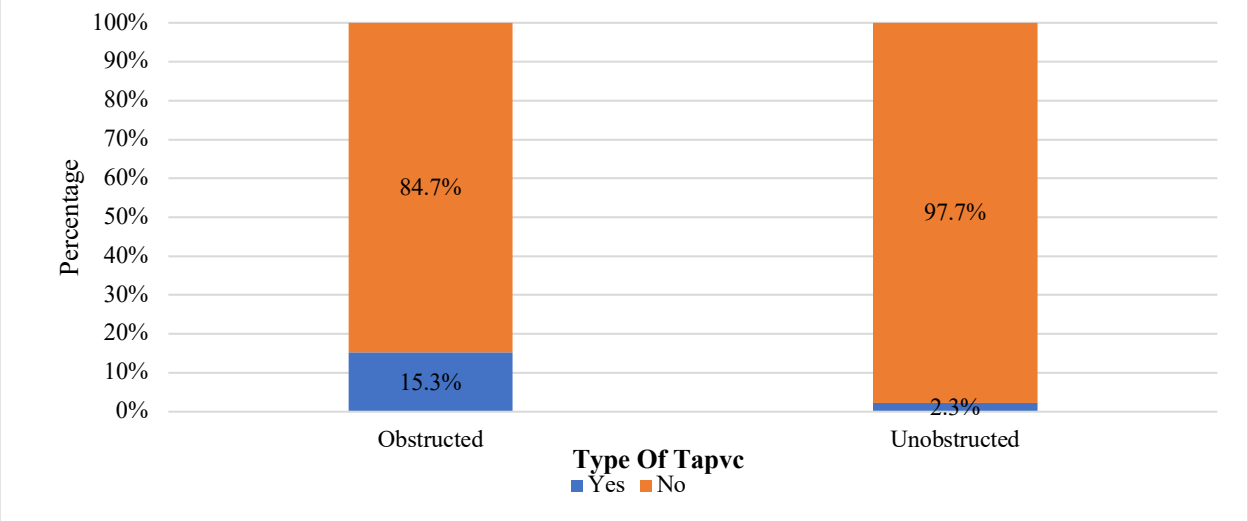


Table 27: Comparison of types of TAPVC for mortality (N=242)

Type Modified	Mortality	
	Yes	No
Supra Cardiac (N=127)	8 (6.3%)	119 (93.7%)
Cardiac (N=57)	8 (14.04%)	49 (85.96%)
IC (N=35)	4 (11.43%)	31 (88.57%)
Mixed (N=23)	1(4.3%)	22 (95.7%)

Table 28: Comparison of mean clamp time across the study groups (N=242)

Age group	CLAMP TIME Mean ± SD	Mean difference	95% CI		P value
			Lower	Upper	
Neonate	81.32 ± 29.27				
Infant	69.46 ± 25.65	11.858	4.01	19.70	0.003
Child	73.87 ± 24.79	7.45	-5.31	20.22	0.251

Table 29: Comparison of mean bypass time across the study groups (N=242)

Age group	BYPASS TIME Mean ± SD	Mean difference	95% CI		P value
			Lower	Upper	
Neonate	149.9 ± 40.52				
Infant	125.65 ± 40.32	24.25	12.28	36.23	<0.001
Child	125.96 ± 42.06	23.94	4.45	43.44	0.016

Table 30: Comparison of median inotropic score (24 hours) across the age group

Age group	Inotropic score Median (IQR)	P value
Neonate	10 (6, 15)	
Infant	6.62 (5, 13)	<0.001
Child	2.5 (0, 9)	

Table 31: Comparison of median of Number of ICU stay across the age group

Age group	Number of ICU stay Median (IQR)	P value
Neonate	10 (7.50, 14.50)	
Infant	6 (4, 8)	<0.001
Child	2 (2, 4)	

Table 32: Correlation between inotropic score (24 hours) and weight, clamp time, temperature (N=240)

	Spearman rank correlation (r_s)	P value
Weight	-0.359	<0.001
Clamp time	0.120	0.063
Temperature	-0.368	<0.001

Figure 29: Scatter plot diagram of correlation between inotropic score (24 hours) and weight (N=240)

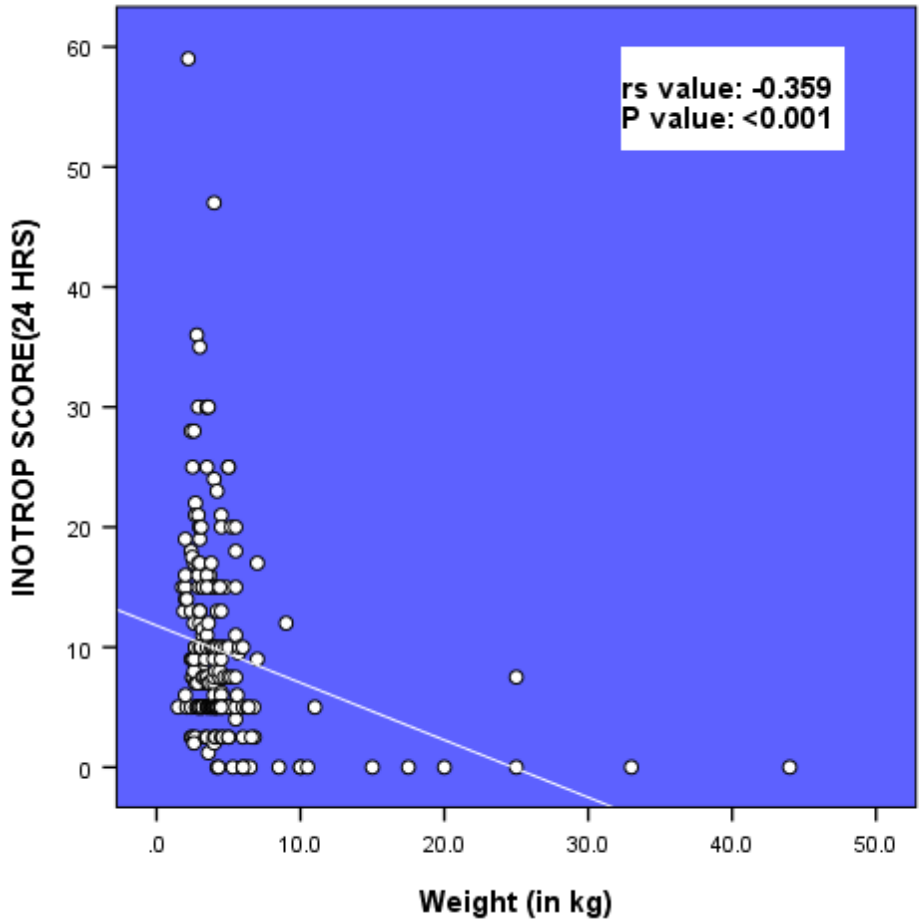


Figure 30: Scatter plot diagram of correlation between inotropic score (24 hours) and clamp time (N=240)

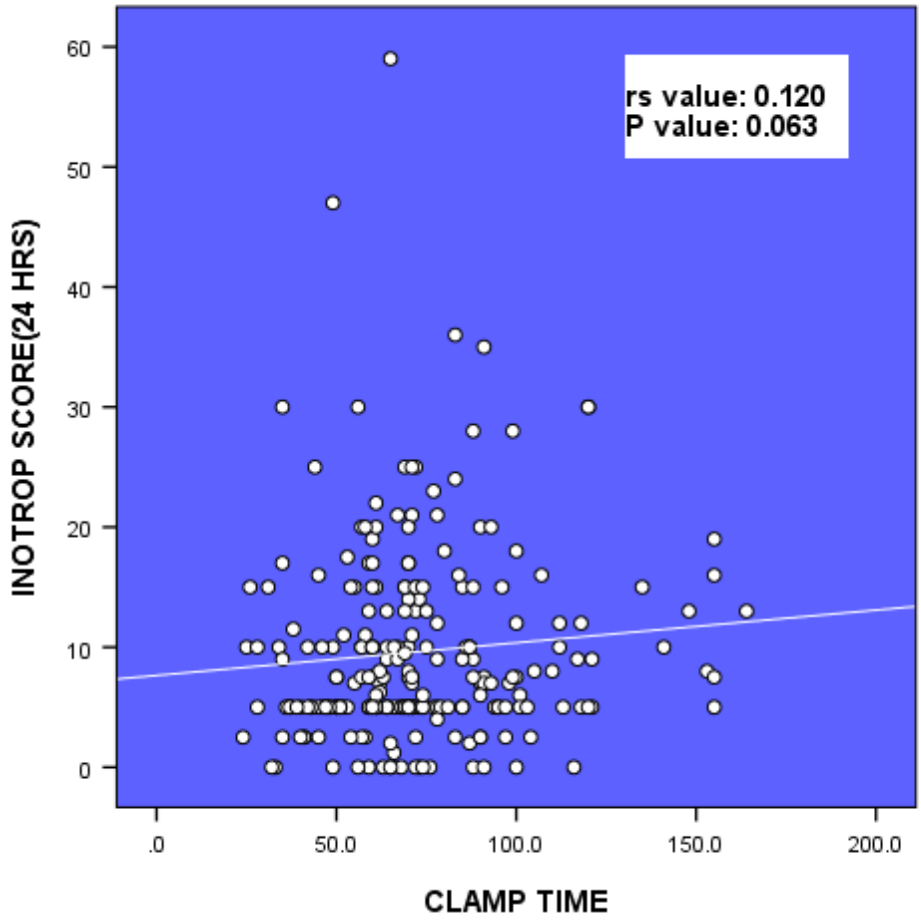


Figure 31: Scatter plot diagram of correlation between inotropic score (24 hours) and Temperature (N=240)

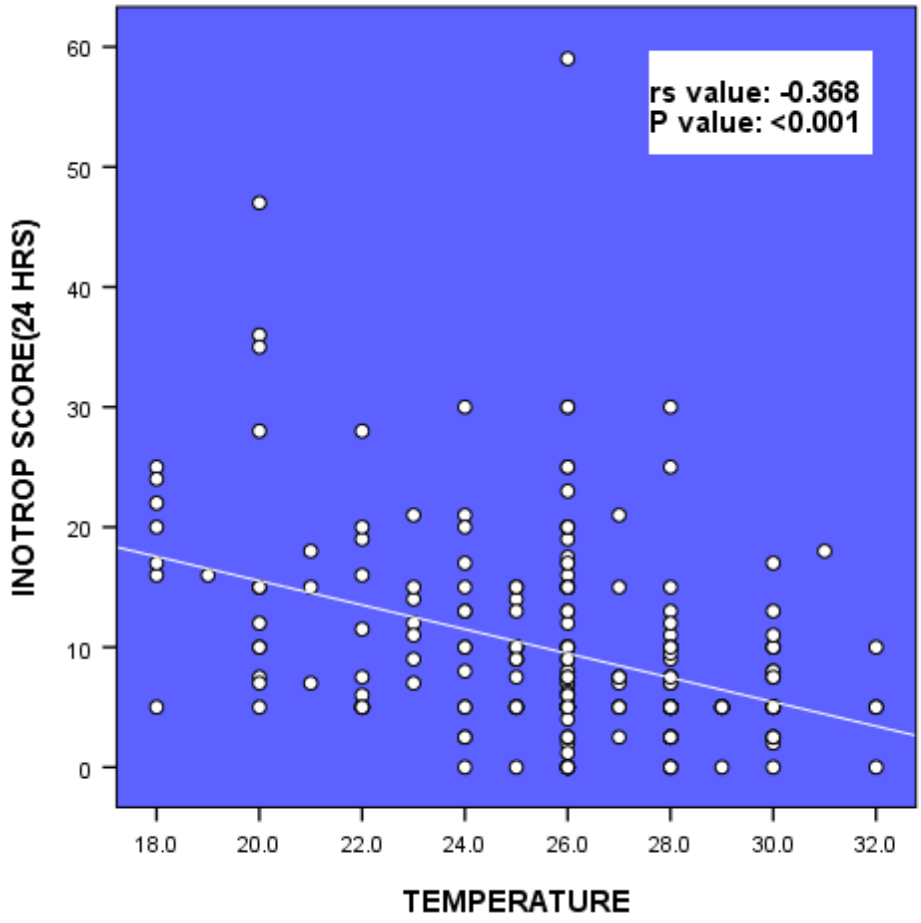


Table 33: Correlation between number of ICU days and weight, clamp time, temperature (N=240)

	Spearman rank correlation (r_s)	P value
Weight	-0.550	<0.001
Clamp time	0.103	0.111
Temperature	-0.251	0.001

Figure 32: Scatter plot diagram of correlation between number of ICU days and weight (N=239)

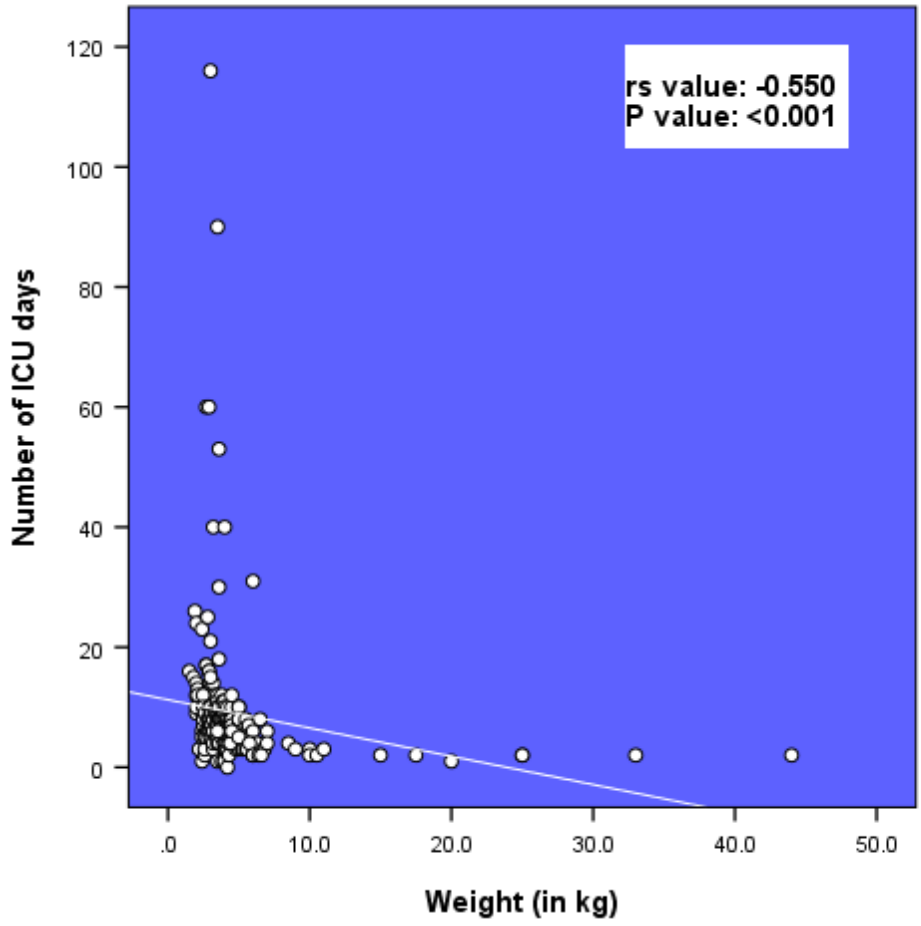


Figure 33: Scatter plot diagram of correlation between number of ICU days and clamp time (N=239)

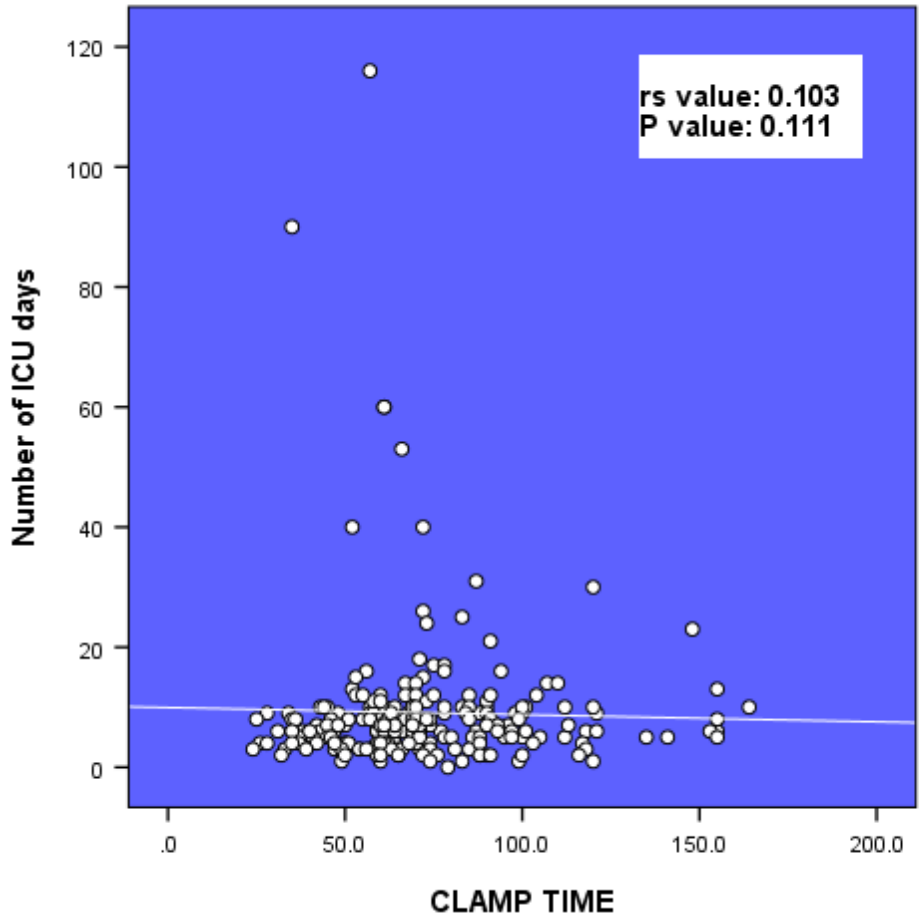


Figure 34: Scatter plot diagram of correlation between number of ICU days and temperature (N=239)

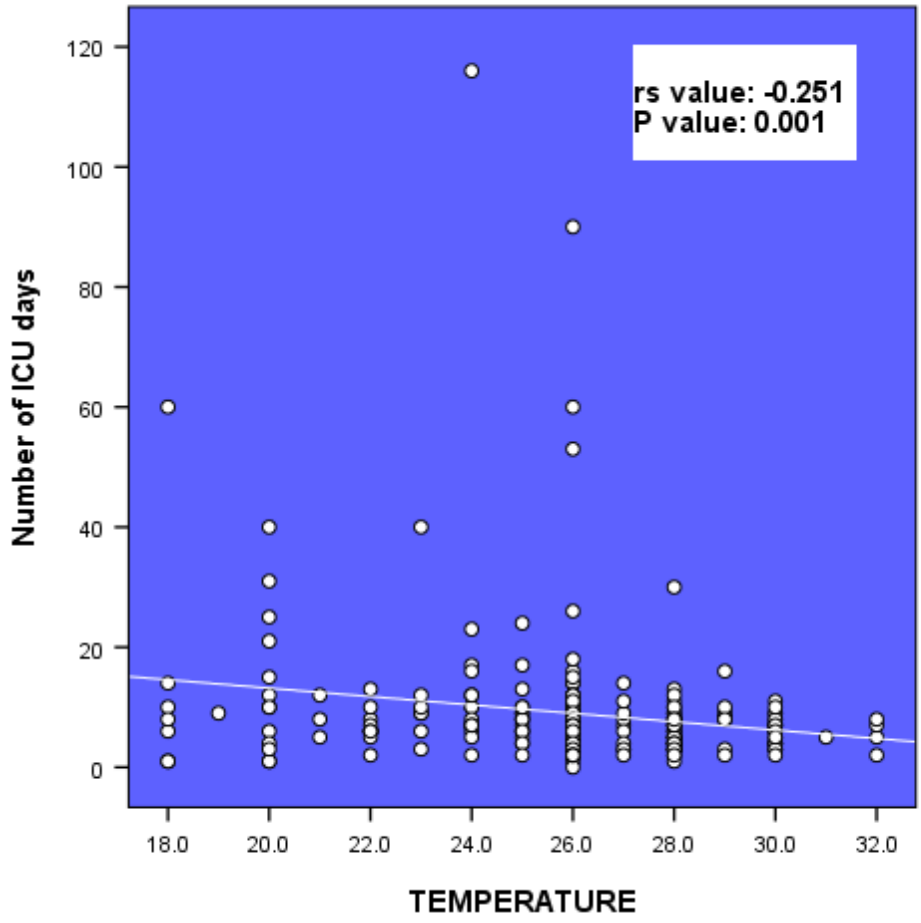


Table 34: Comparison of techniques between reoperation (procedure) (N=242)

Techniques	Reoperation (Procedure)		Chi square	Fisher exact P value
	Yes	No		
Primary Suturless (N=111)	3 (2.7%)	108 (97.3%)	0.026	1.000
Others (N=131)	4 (3.05%)	127 (96.95%)		

Table 35: Comparison of techniques between mortality (N=242)

Techniques	Mortality		Chi square	P value
	Yes	No		
Primary Suturless (N=111)	5 (4.5%)	106 (95.5%)	3.824	0.050
Others (N=131)	16 (11.45%)	115 (88.55%)		

Table 36:Comparison of various parameters between type of TAPVC(univariate logistic regression)

	Obstructed (N=111)	Unobstructed (N=131)	Unadjusted odds ratio	P value
Intra operative				
Clamp Time (Mean±SD)	78.84±27.64	67.91±25.33	1.016 (1.006-1.026)	0.002
Bypass Time (Mean±SD)	143.43±40.35	122.11±40.5	1.013 (1.006-1.020)	<0.001
Immediate Post operative				
VIS	9(5,15)	5(2.50,10)	*	*
PV flow at 5 year follow up				
Laminar (N=231)	104(50.24%)	127(49.76%)		
Turbulent(N=10)	7(70%)	3(30%)	3.218 (0.809-12.78)	0.097
Obstructed (N=1)	0	1(100%)	0.000	1.00
Reintervention	6(85.7%)	1(14.3%)	0.135 (0.016-1.136)	0.065

Table 37 : Comparison of various parameters between technique (univariate logistic regression)

	SUTURELESS (N=111)	OTHERS (N=131)	Unadjusted odds ratio	P value
Intra operative				
Clamp Time (Mean±SD)	76.14±24.09	70.2±28.91	1.008 (0.999-1.018)	0.089
Bypass Time (Mean±SD)	135.42±36.16	128.9±45.85	1.004 (0.998-1.010)	0.226
Immediate Post operative				
VIS	7(5,10)	9(5,15)	*	*
PV flow at 5 year follow up				
Laminar (N=207)	103(49.76%)	104(50.24%)		
Turbulent(N=10)	3(30%)	7(70%)	0.433 (0.109-1.720)	0.234
Obstructed (N=1)	0	1(100%)	0.000	1.00
Reintervention	3(85.7%)	4(14.3%)	0.882 (0.193-4.027)	0.871

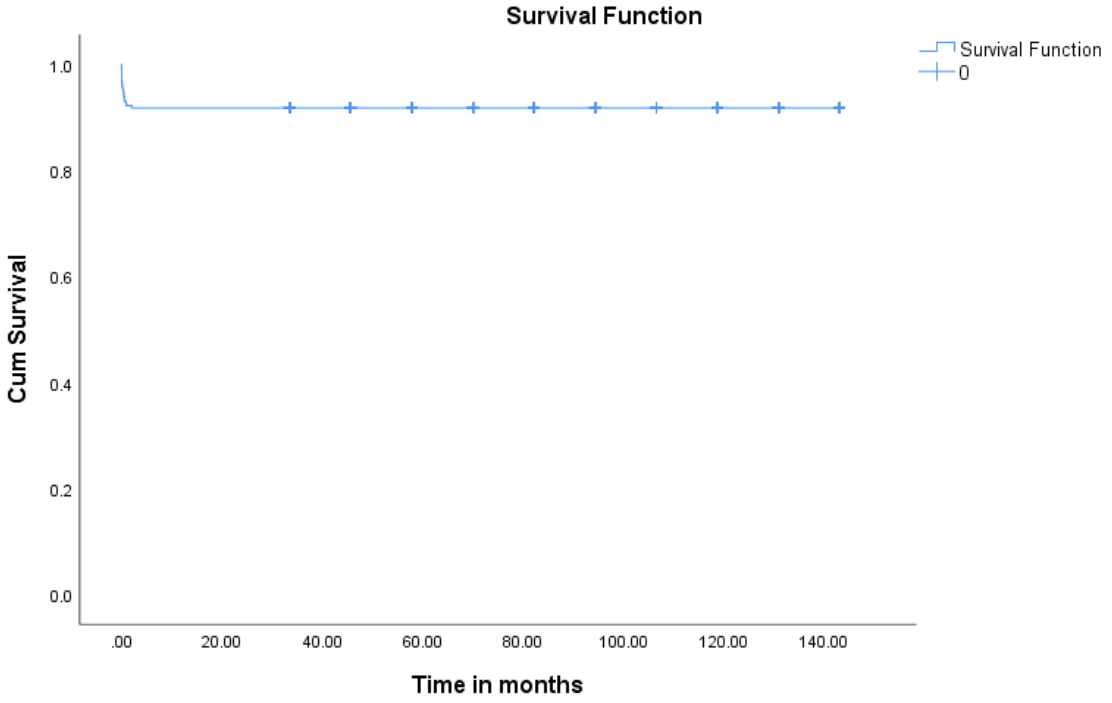
Table 38: SUTURLESS VS CONVENTIONAL SURGICAL REPAIR

	SUTURLESS					CONVENTIONAL REPAIR				
VARIABLE	OVERALL	Supracardiac	Cardiac	Infracardiac	mixed	Overall	Supracardiac	Cardiac	Infracardiac	mixed
PATIENTS	111	79	10	29	2	131	48	47	6	21
AGE(MEDIAN) DAYS	60	90	51	8	90	105	120	90	16	120
WEIGHT(KG)	3.94+/-6.3	4.3+/-7.1	4.02+/-5	2.94+/-3.5	4+/-5	5.11+/-5.30	6.24+/-7/53	4.42+/-7.5	3.2+/-4.14	4.75+/-6.8
PRE OP PVO	70	34	5	29	2	41	13	18	5	5
CPBCPB TIME(MIN)	135.42+/-36.16	130+/-35	115+/-59	144+/-29	152+/-42	128.9+/-45.85	148+/-30.6	103+/-49	164+/-44	128+/-27.68
CLAMP TIME(MIN)	76.14+/-24.09	71+/-22	72+/-26	81+/-20	102+/-26	70.2+/-28	74+/-17.07	62+/-37	86+/-29	77+/-26.33
MORTALITY	5	1	2	2	0	16	7	6	2	1
REINTERVENTION	3	0	0	1	2	4	1	2	0	1
FOLLOWUP (TURBULENT/ OBSTRUCTED FLOW)	9	2	2	4	1	26	12	8	3	3

Table 39: Summary of overall survival time in entire study population

Means for Survival Time			
		95% Confidence Interval	
Estimate	Std. Error	Lower Bound	Upper Bound
131.239	2.525	126.290	136.189

Figure 35: Kaplan Meier curve of overall survival time in entire study population



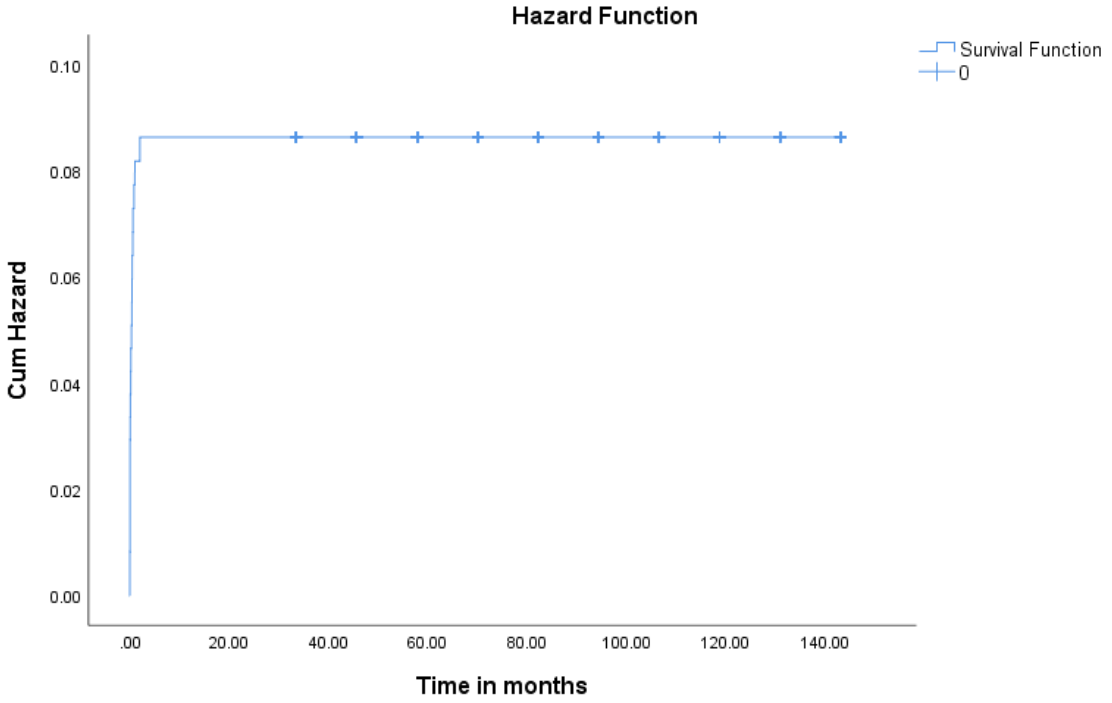
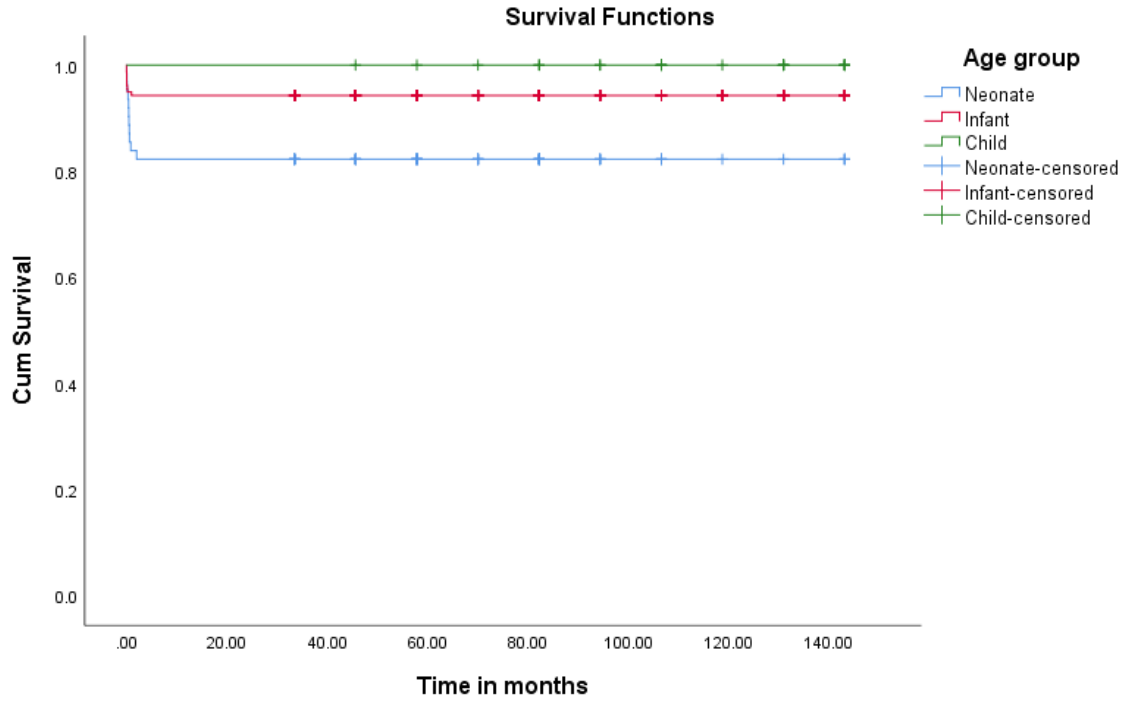


Table 40: Comparison of mean survival time in months across different age group

Case Processing Summary				
			Censored	
Age group	Total N	N of Events	N	Percent
Neonate	62	12	50	82.3%
Infant	157	9	148	94.3%
Child	23	0	23	100.0%
Overall	242	20	222	91.7%

Overall Comparisons			
	Chi-Square	df	P value
Log Rank (Mantel-Cox)	10.421	2	.005
Breslow (Generalized Wilcoxon)	9.939	2	.007
Tarone-Ware	10.180	2	.006
Test of equality of survival distributions for the different levels of Age group.			

Figure 36: Kaplan-Meier curves comparing the survival time across different age group



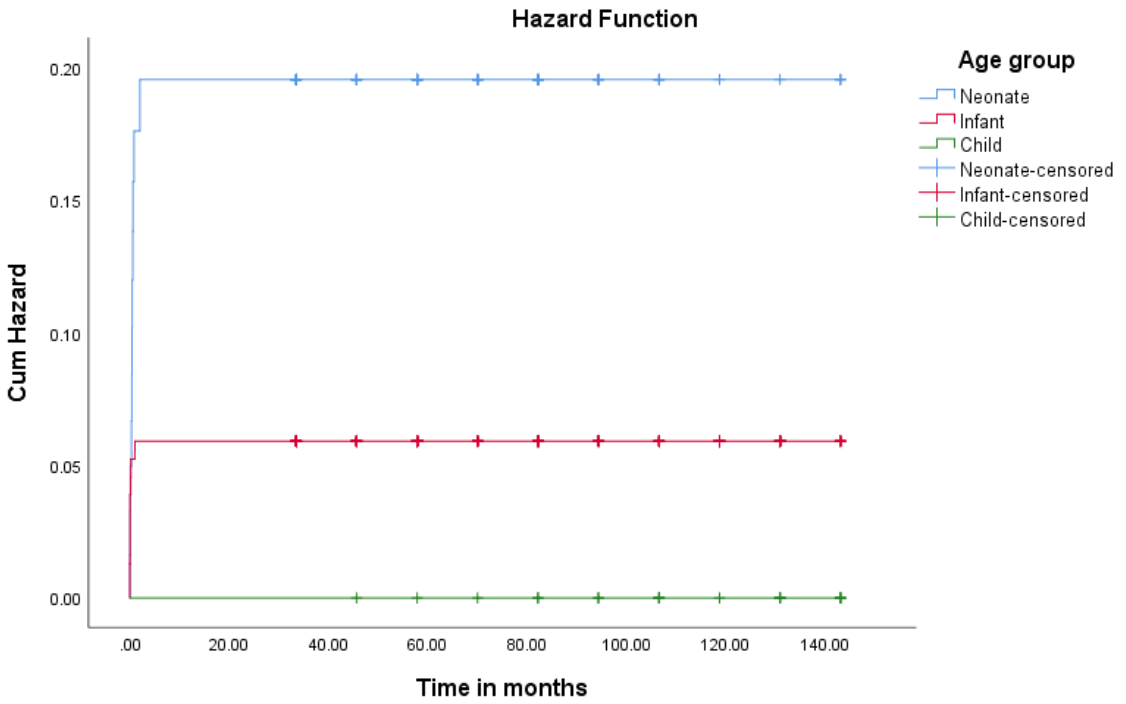


Table 41: Comparison of mean survival time in months between gender

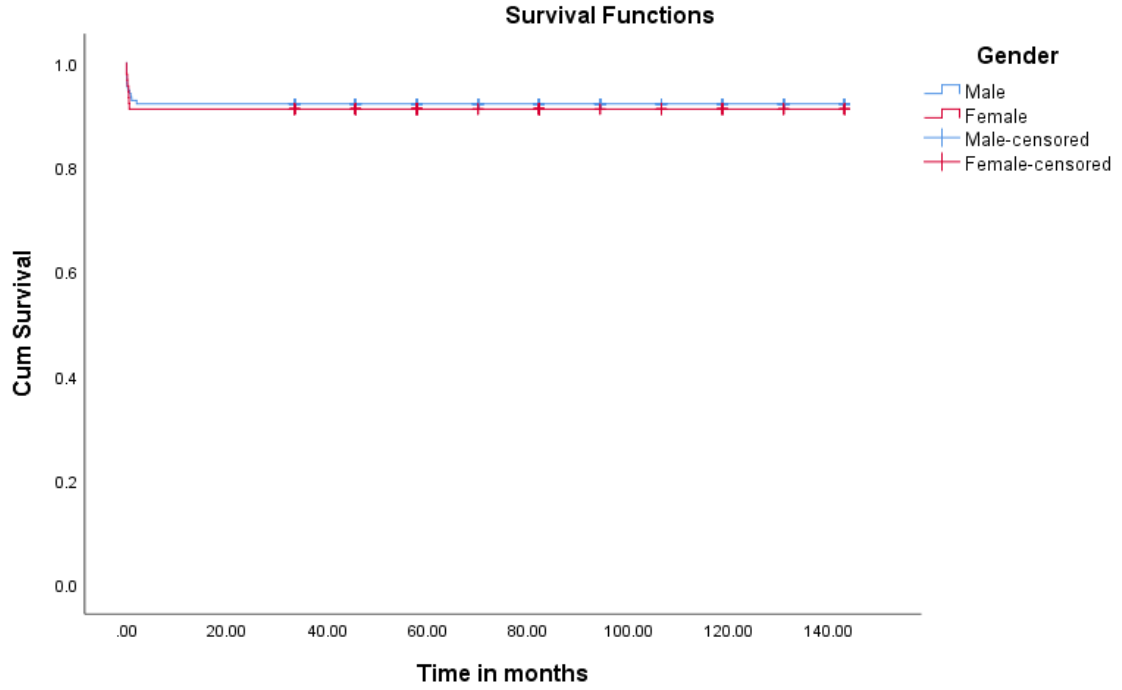
Case Processing Summary				
			Censored	
Gender	Total N	N of Events	N	Percent
Male	152	12	140	92.1%
Female	90	8	82	91.1%
Overall	242	20	222	91.7%

	Means for Survival Time			
			95% Confidence Interval	
Gender	Estimate	Std. Error	Lower Bound	Upper Bound
Male	131.771	3.119	125.658	137.885
Female	130.341	4.282	121.948	138.734
Overall	131.239	2.525	126.290	136.189

Overall Comparisons			
	Chi-Square	df	P value
Log Rank (Mantel-Cox)	.079	1	.778
Breslow (Generalized Wilcoxon)	.078	1	.780
Tarone-Ware	.079	1	.779

Test of equality of survival distributions for the different levels of Gender.

Figure 37: Kaplan-Meier curves comparing the survival time between gender



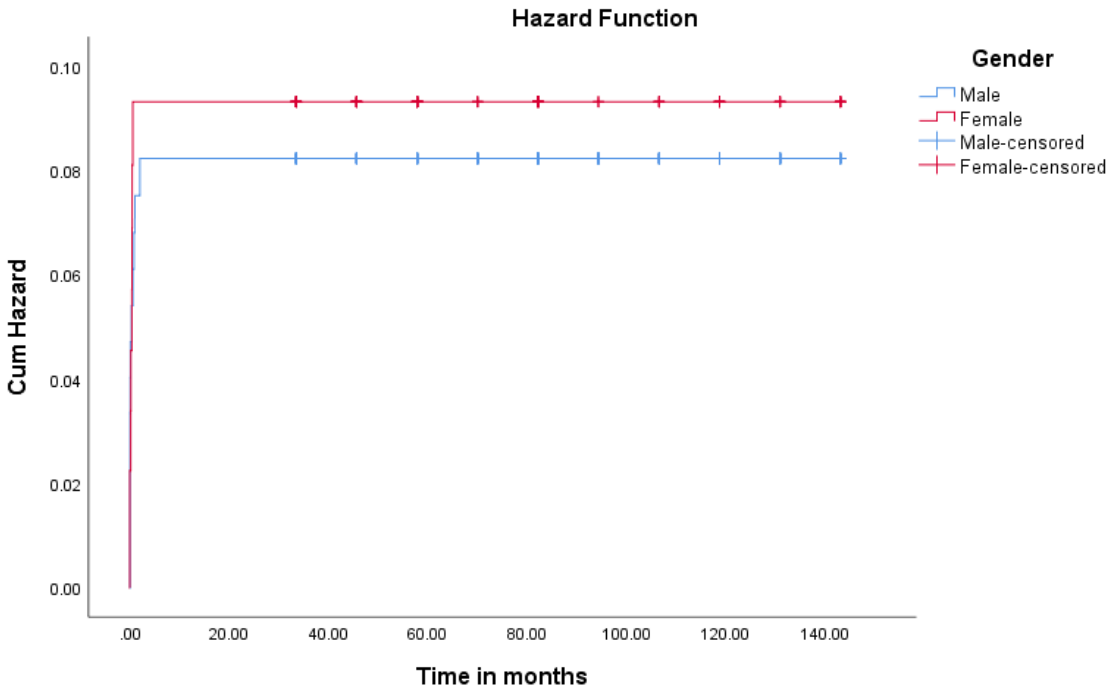


Table 42: Comparison of mean survival time in months between different type of TAPVC

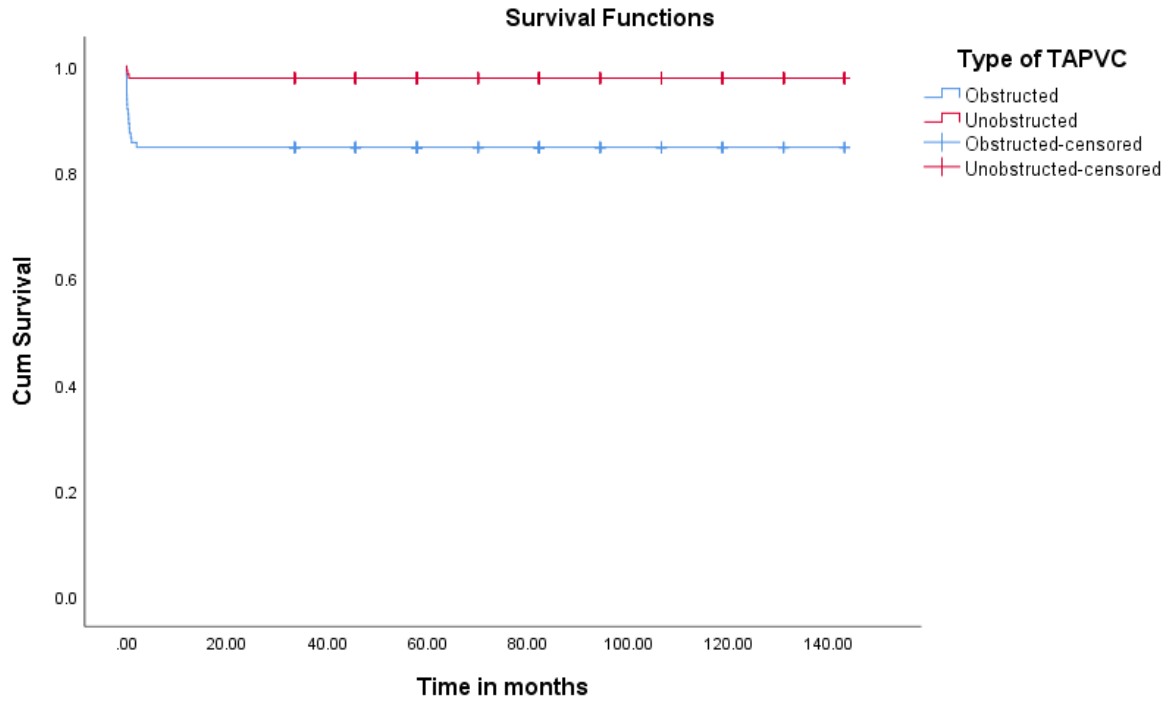
Case Processing Summary				
			Censored	
Type of TAPVC	Total N	N of Events	N	Percent
Obstructed	111	18	93	84.7%
Unobstructed	131	3	128	97.7%
Overall	242	20	222	91.7%

	Means for Survival Time			
			95% Confidence Interval	
Type of TAPVC	Estimate	Std. Error	Lower Bound	Upper Bound
Obstructed	121.184	4.876	111.627	130.741
Unobstructed	139.760	1.866	136.102	143.418
Overall	131.239	2.525	126.290	136.189

Overall Comparisons			
	Chi-Square	df	P value
Log Rank (Mantel-Cox)	13.465	1	<0.001
Breslow (Generalized Wilcoxon)	13.425	1	.000
Tarone-Ware	13.447	1	.000

Test of equality of survival distributions for the different levels of Type of TAPVC .

Figure 38: Kaplan-Meier curves comparing the survival time between different type of TAPVC



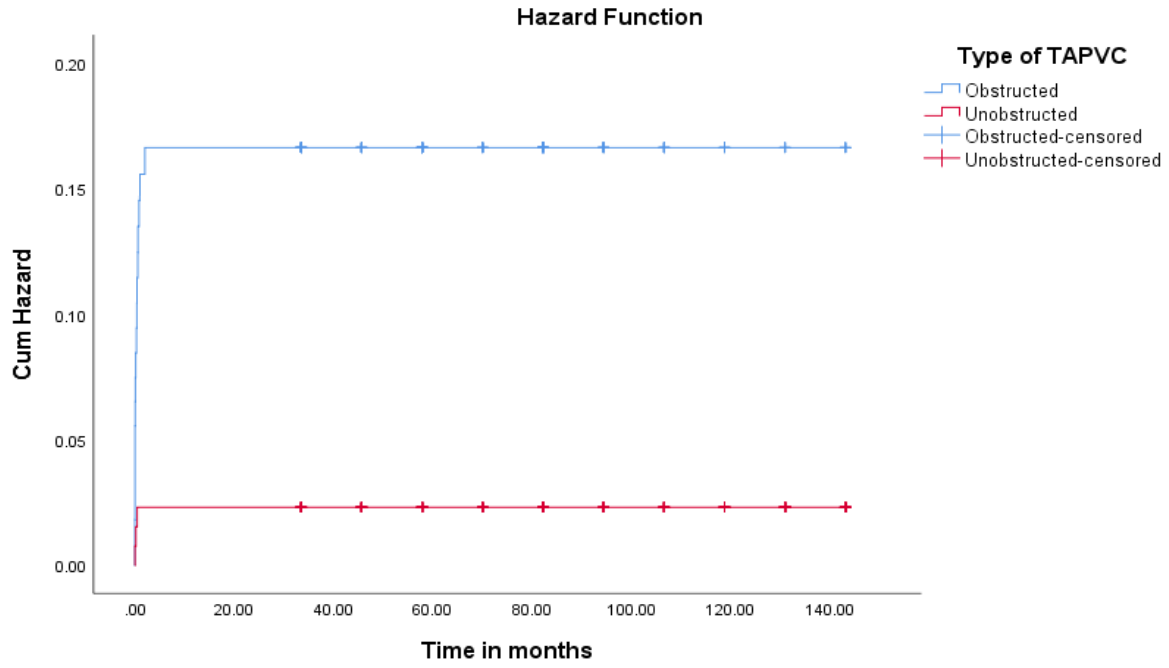


Table 43: Comparison of mean survival time in months between <3 kg and 3kg and more weight patients

Case Processing Summary

Weight (< 3 kg)	Total N	N of Events	Censored	
			N	Percent
Yes	50	10	40	82.0%
No	192	11	181	94.3%
Overall	242	20	222	91.7%

Means for Survival Time

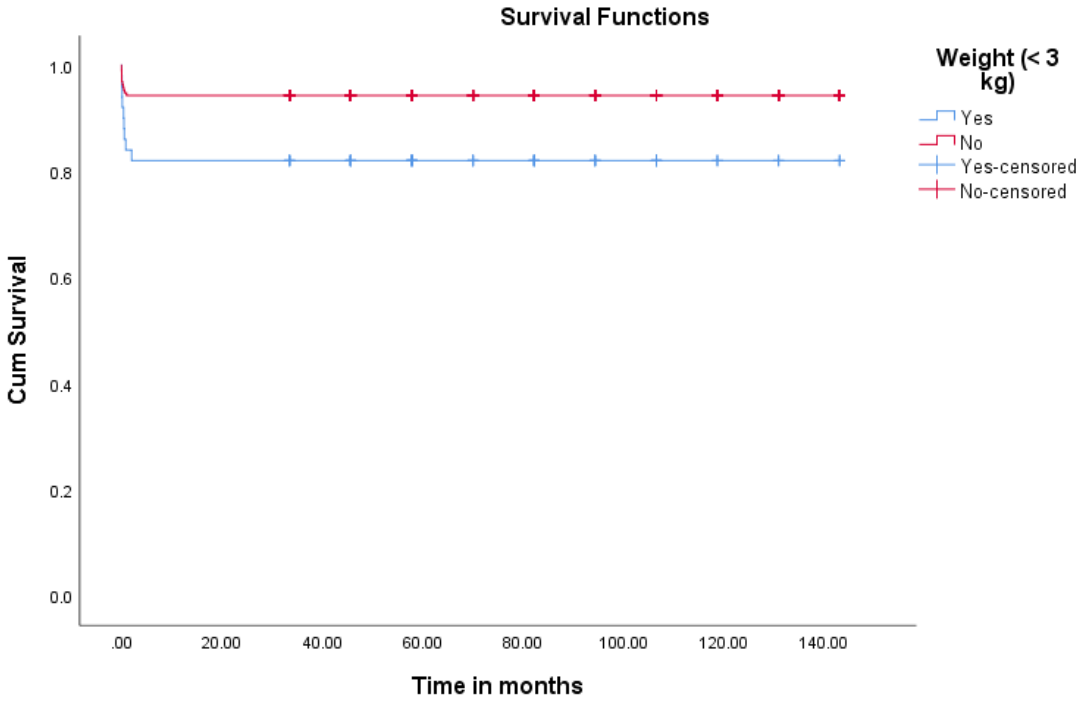
Weight (< 3 kg)	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Yes	117.377	7.743	102.201	132.554
No	134.849	2.395	130.155	139.543
Overall	131.239	2.525	126.290	136.189

Overall Comparisons

	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	7.794	1	.005
Breslow (Generalized Wilcoxon)	7.471	1	.006
Tarone-Ware	7.634	1	.006

Test of equality of survival distributions for the different levels of Weight (< 3 kg).

Figure 39: Kaplan-Meier curves comparing the survival time between <3 kg weight AND >3KG PATIENTS



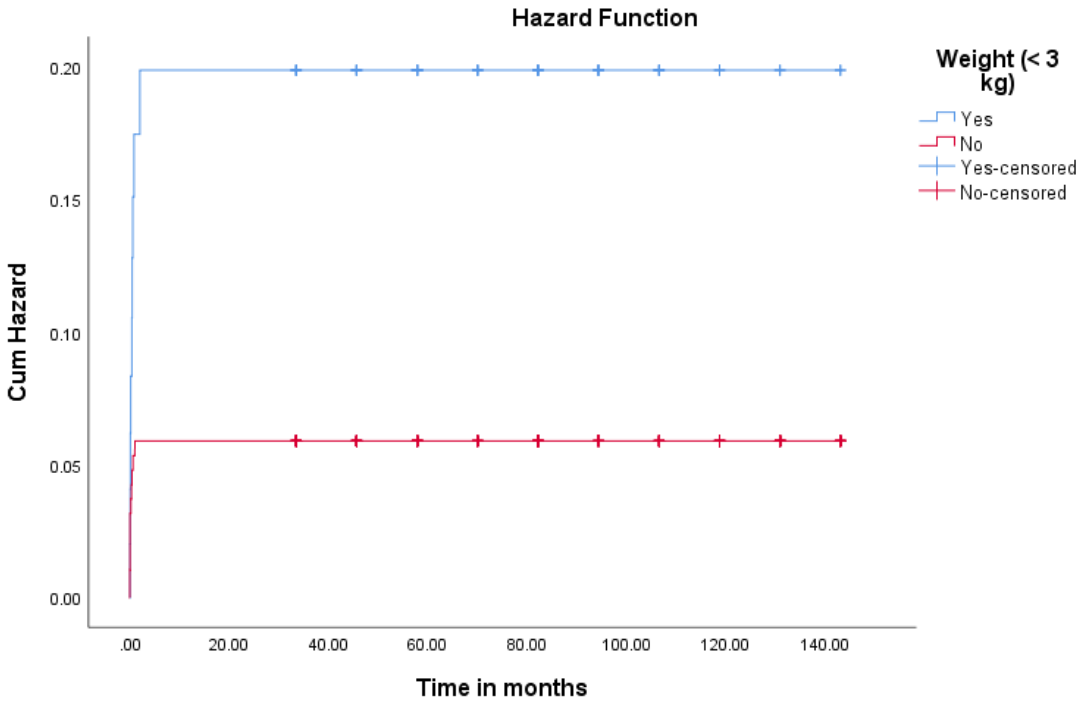


Table 44: Comparison of mean survival time in months between different PH level <7.35

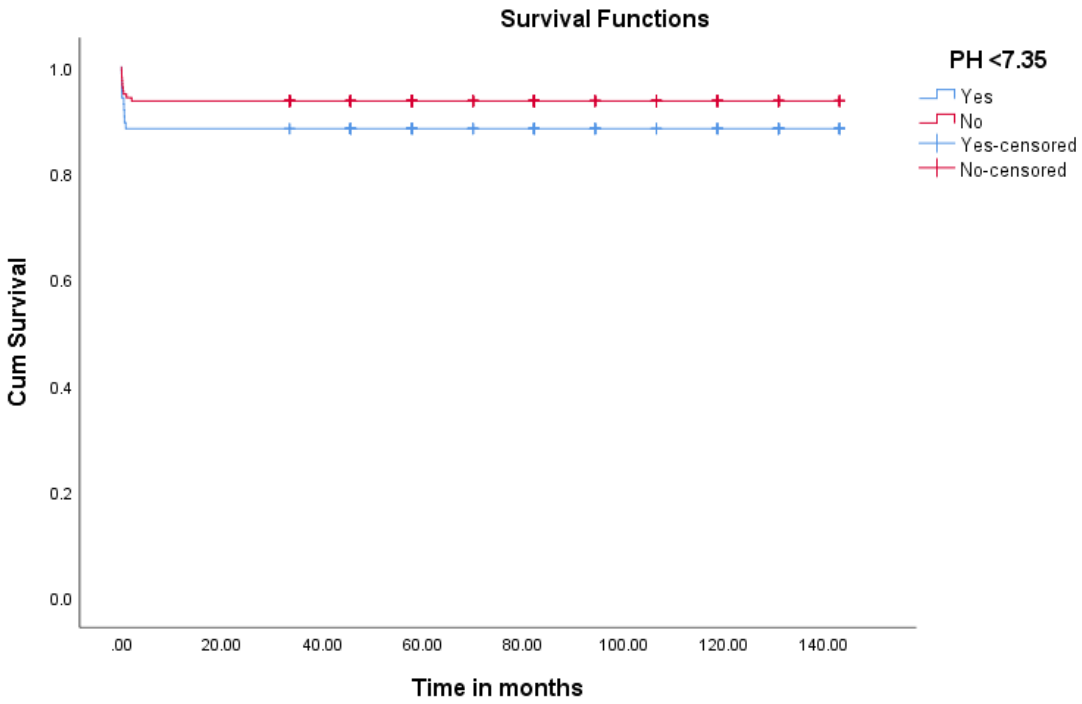
Case Processing Summary				
			Censored	
PH <7.35	Total N	N of Events	N	Percent
Yes	86	10	76	88.4%
No	156	11	145	93.6%
Overall	242	20	222	91.7%

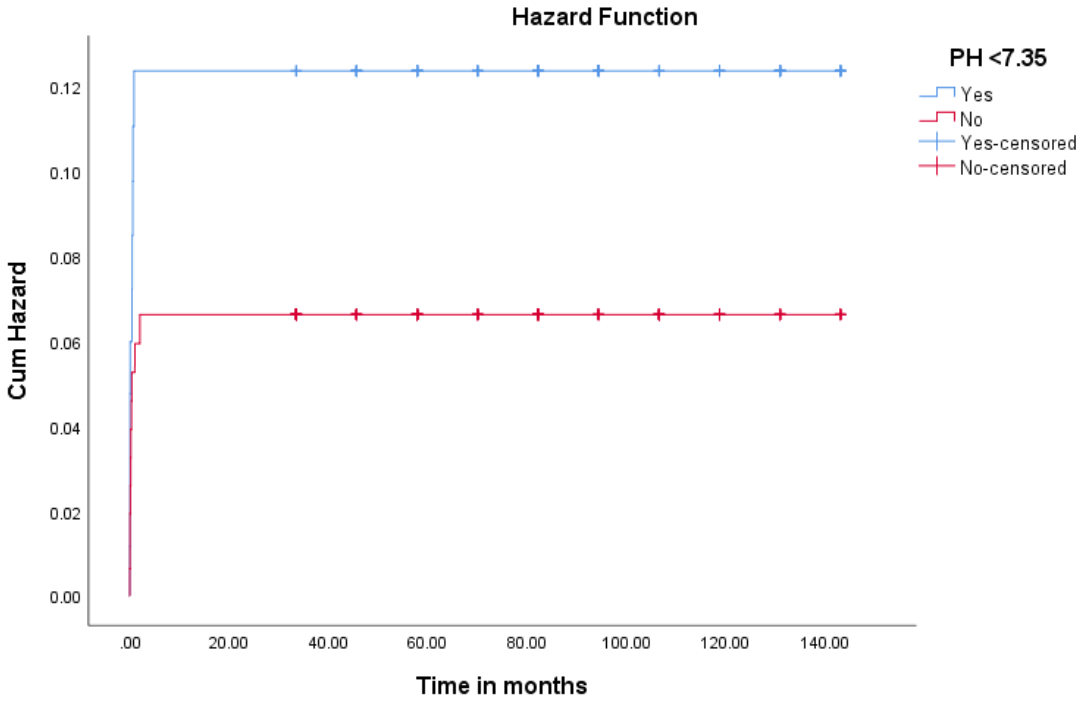
	Means for Survival Time			
			95% Confidence Interval	
PH <7.35	Estimate	Std. Error	Lower Bound	Upper Bound
Yes	126.434	4.934	116.764	136.104
No	133.889	2.797	128.407	139.370
Overall	131.239	2.525	126.290	136.189

Overall Comparisons			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	1.993	1	.158
Breslow (Generalized Wilcoxon)	1.997	1	.158
Tarone-Ware	1.995	1	.158

Test of equality of survival distributions for the different levels of PH <7.35.

Figure 40: Kaplan-Meier curves comparing the survival time between different PH level





RESULTS

There was a total of 242 (n=242) patients in the cohort. The male to female ratio was 1.6:1. Based on the age 25.62% (n=62) were neonates, 64.88% (n=157) were infants and only 9.5% (n=23) were children more than 1 year old. The patients' mean weight was 4.57+- 4.22 Kilos, and the median weight was 3.8 kilos. 20.7% (n=50) of patients had weight less than 3kilos at the time of presentation.

The most common type of TAPVC was the Supracardiac type, with 127 patients (52.4%) followed by cardiac type 57 patients (23.5%). There were 35 patients (14.5%) with infracardiac type of TAPVC, and the least common type was the mixed type with 23 patients (10%). 111 patients (45.8%) presented with obstruction of the pulmonary venous circulation, while 131(54.2%) patients did not demonstrate any pulmonary venous obstruction features. Based on the type of TAPVC, 37% (n=47) of Supracardiac TAPVC, 40.3% (n=23) of cardiac TAPVC, 97.2% (n=34) of infracardiac TAPVC and 30.4% (n=7) of mixed TAPVC presented with obstruction. The incidence of obstruction was noted to be extremely high for the infracardiac type of TAPVC.

Comparison of intraoperative, ICU, and 5-year follow-up variables between obstructed and unobstructed TAPVC has been mentioned in Table 36. 65.7% (n=159) were diagnosed to have severe PAH and 17.7% (n=43) had moderate PAH. Before surgery, the mean Blood PH in the cohort was 7.37+- 0.1 with minimum PH recorded to be 6.85. 35.5% (n= 86) had an acidotic PH (PH <7.35) at the time of induction for surgery, with ten patients, had severe acidosis (PH < 7.2).

The most common type of surgical correction performed in the study Cohort was Sutureless technique in 111 patients (45.9%), followed by cut-back technique in 60 patients (24.8%), Modified Schumaker King technique in 36 patients (14.9%) and the posterior technique in 35 patients (14.6%). There was no difference noted in intraoperative and postoperative variables between the sutureless and conventional techniques (Table 37,38). The comparison of pulmonary venous flow variables at 5 years between sutureless and non-sutureless techniques was similar (Table 37). The mean clamp time for the whole cohort was 72.9+- 26.9 minutes. The mean clamp time in neonates was 81.3+- 29.3 minutes, which was higher when

compared to infants (69.46+-25.65 minutes), and children (73.87+-24.79) was statistically significant (p-value 0.003). The mean By-pass time was 131.9 +- 41.7 minutes for the whole cohort. The mean By-pass time for neonates was 149+- 40.5 minutes, which was higher when compared to infants (125.6+-40.3minutes) and children (125.9+-42.06 minutes) and statistically significant (p-value <0.001). Only 5 patients required Total circulatory Arrest (TCA).

The mean ICU stay was 9.1+- 11.8 days. The median ICU stay for neonates was 10 days, which was higher when compared to infants (6days) and children (2days) (P-value <0.001). The duration of ICU stay had a moderately significant negative correlation with weight (Spearman rank correlation -0.55). The mean vasoactive inotropic score (VIS) of these patients was 9.62+-8.1. The VIS for neonates was 10 and, when compared to infants (VIS=6.6) and children (2.5) was higher (p-value <0.001). The VIS had a negative correlation with weight and temperature during By-pass. Both ICU duration and VIS scores did not correlate with the duration of clamp time. The mean postoperative PA pressures were 24.4+-8.2 mmHg. 9 patients develop PAH crisis during the postoperative ICU stay. There were 18(7.4%) early mortality in this cohort and 2 late mortality (0.09%).
The mortality according to the anatomical type was as follows, 8 in Supracardiac type, 8 in cardiac type, 4 in infracardiac type, and none in mixed type. The most common cause of mortality was sudden cardiac death secondary to PA crisis and sepsis. 2 late mortality was due to sudden cardiac death at home. Atrial Arrhythmias was the most common early postoperative complication noticed in 3.7% (n= 9).

The overall survival of the cohort is 91.3% (n=221). Based on the Kaplan Meir curve, the 10-year survival of neonates, infants, and children is 82.3%, 94.3%, and 100%, respectively (Fig 32). The 10-year survival of patients with obstructed TAPVC is 84.7% and 97.7% for unobstructed TAPVCs (Fig 34), which was found to be statistically significant (p value<0.001). Based on the weight at the time of surgical correction, the survival at 10 years 82% (n=41) in patients weighing less than 3kilos and 94.3% (n=181) in patients weighing more than 3 kilos.

DICUSSION

In our study we found that

- Pulmonary venous obstruction is the single most important pre-operative variable having an effect on post-operative outcome and survival.
- Weight less than 3 kgs is a risk factor for immediate post-operative period in terms of increased VIS and ICU stay. There is an early hazard associated with weight less than 3 kg. However, there is no effect on long term survival.

Comparing the mean/median weight of the patients in the current study with the previous studies ,no significant difference was found .

TABLE 45

S.NO	STUDY	MEAN/MEDIAN WEIGHT(kg)
1	Guocheng Shi et al	5.4+/-3.6
2	Chun -Min Fu et al	3.49+/-1.10
3	Choudhary et al	3.7+/-0.27
4	Camille L. Hancock Friesen et al	3.60
5	Sakamoto et al	5.5+/- 6.0
6	Karamlou et al	3.9+/-1.9
7	Current study	4.67+/-4.22(median 3.80)

- Number of patients with pulmonary venous obstruction were maximum in infracardiac type (97%) followed by cardiac type with 42 % .

Comparing with previous studies: No significant difference was obtained.

TABLE 46

S.NO	STUDY	PVO(%)
1	Guocheng Shi et al	25
2	Chun -Min Fu et al	57.7
3	Choudhary et al	48
4	Camille L. Hancock Friesen et al	54.7
5	Sakamoto et al	30.3
6	Karamlou et al	48
7	Hörer et al	53.7
8	Current study	45.87

- 43 % of unobstructed TAPVC patients also presented with severe PAH. This suggests that even in the absence of echocardiographic demonstration of obstruction , the drainage pathway in a TAPVC can be inherently obstructed or an increased pulmonary blood flow can result in severe PAH

- Increased clamp time or bypass time had weak -ve correlation with post-operative VIS and duration of ICU stay . Neither of the two had an effect on long term survival of the patients. Hence a proper anastomosis between the common chamber and the left atrium is most important, even if the time for the procedure is more.

- Operating the patients at moderate hypothermia rather than deep hypothermia had a statistically significant effect on post-operative VIS and duration of ICU stay .Neither of the two had an effect on long term survival.

- We used Primary sutureless technique in 111 patients(45.87%).Remaining patients were operated with anastomoses of Common chamber to LA wall directly. Primary sutureless technique was adopted on the grounds of reduced post-operative pulmonary venous stenosis and improved outcome(24). However, there was no statistical significance difference between the two groups i.e., sutureless technique vs conventional techniques in terms of post-operative outcome and the need for re-intervention.

- Post Repair:

  7 patients underwent reintervention out of which 3 underwent sutureless repair. Out of these 7 patients 7 had obstructed anatomy. As far as type of TAPVC is concerned,3 were mixed type,2 cardiac type and one each of supracardiac and infracardiac type.

- MORTALITY

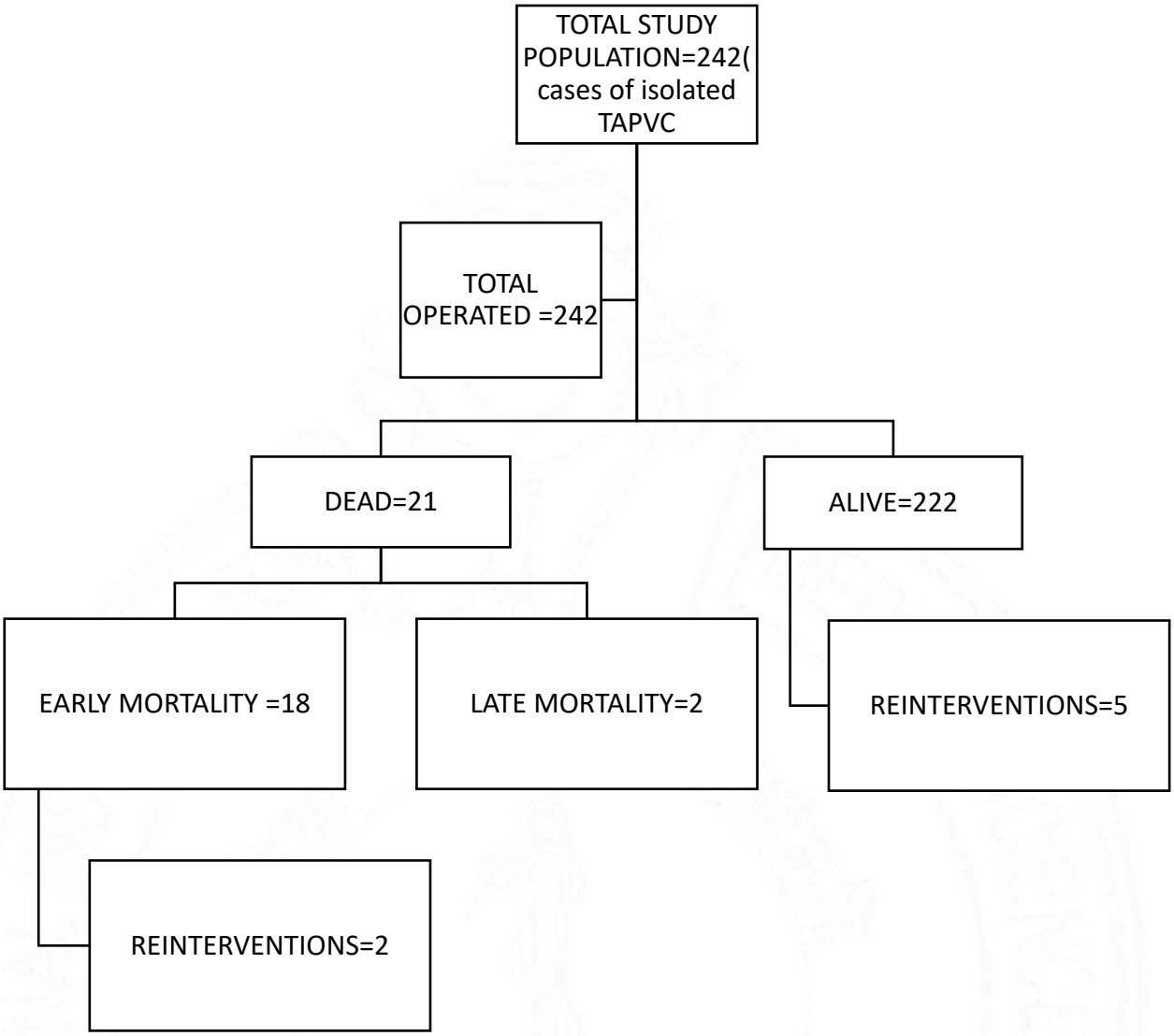

TOTAL STUDY POPULATION=242(cases of isolated TAPVC
TOTAL OPERATED =242
DEAD=21
ALIVE=222
EARLY MORTALITY =18
LATE MORTALITY=2
REINTERVENTIONS=5
REINTERVENTIONS=2

FIGURE 41

S.NO	YEAR	AGE	WEIGHT	OBST/UNOBS	ADD	TYPE	PV SCORE	PAH	CLAMP	PUMP	TEMP AND TCA	SURGERY	EMERG	VIS	ICU	CAUSE	REINT
1.	2,008	3M	4	Unobstructed	DIAPHRAGMATIC HERNIA	Supra cardiac	0	Moderate	49	240	20	POSTERIOR APPROACH	N	47	1	LOW CARDIAC OUTPUT, POST OP CARDIAC TAPVC WITH EVENTERATION OF RIGHT HEMIDIAPHRAGM	
2.	2,008	2M	3	Obstructed	PDA	Supra cardiac	0	Severe	91	182	20	WILLIAM	N	35	21	SEPTICEMIA	
3.	2,008	7M	4	Obstructed	PDA	Supra cardiac	2	Severe	83	206	18/Y (10+35+25MIN)	WILLIAM	N	24	1	SEVERE BIVENTRICULAR DYSFUNCTION	
4.	2,008	6M	7	Unobstructed		CARDIAC	0	Severe	35	114	26	VAN PRAGH	N	17	6	RESPIRATORY FAILURE	
5.	2,008	3Y	7	Unobstructed	PDA	MIXED	0	Moderate	35	105	25	POSTERIOR APPROACH	N	9	4	SUDDEN CARDIAC ARREST	
6.	2,009	20D	2.4	Obstructed		Supra cardiac	0	Severe	99	200	20	SCHUMAKER KING	N	28	1	PAH CRISIS,CARDIAC ARREST	
7.	2,010	21D	2.6	Obstructed		Supra cardiac	2	Severe	88	190	22	MOD SHUMAKER AND KING	N	28	2	PAH CRISIS,CARDIAC ARREST	
8.	2,010	2D	3.8	Obstructed		Supra cardiac	0	Severe	60	115	18	TAPVC REPAIR	N	17	1	CARDIAC ARREST	
9.	2,010	4M	3.5	Obstructed		CARDIAC	0	Severe	120	170	26	CS CUTBACK	N	30	1	CARDIAC ARREST	
10.	2,010	2M	2.8	Obstructed	PDA	IC	3	Severe	83	151	20	POSTERIOR APPROACH	Y	36	25	SEPTICEMIA WITH MODS	
11.	2,012	1D	3.6	Obstructed	PDA	Supra cardiac	2	Severe	71	205	26	TAPVC REPAIR	N	5	18	SEPTICEMIA	
12.	2,012	29D	3	Obstructed		CARDIAC	0	Severe	129	144	20	CS CUTBACK	N				
13.	2,013	2M	3	Obstructed		CARDIAC	2	Severe	155	236	22	CUTBACK	N	19	13	SEPTICEMIA,MODS	
14.	2,013	5D	4.2	Obstructed		IC	0	Severe	79	150	26	SUTURLESS	N	5	0	SEVERE BIVENTRICULAR DYSFUNCTION	
15.	2,013	3M	2.4	Obstructed	PDA	IC	0	Severe	100	159	21	SUTURLESS	N	18	5	PAH CRISIS,CARDIAC ARREST	
16.	2,014	49D	2.2	Obstructed	PDA	Supra cardiac	0	Severe	65	129	26	SUTURLESS	N	59	3	SYSTEMIC RV,CARDIAC ARREST	
17.	2,016	22D	2.9	Unobstructed	PDA	CARDIAC	0	Severe	67	150	27	CUTBACK	N	21	14	SYSTEMIC RV,CARDIAC ARREST	CC-CS OBSTRUCTION
18.	2,016	5D	3	Obstructed		CARDIAC	3	Severe	34	74	30	CUTBACK	N	10	9	SYSTEMIC RV,CARDIAC ARREST DUE TO PA CRISIS AND BRONCHOPNEUMONIA	CC-LA OBSTRUCTION

FIGURE 42

TABLE 47

S.NO	STUDY	MORTALITY(%)
1	Guocheng Shi et al	6
2	Chun -Min Fu et al	9
3	Choudhary et al	23.3
4	Camille L. Hancock Friesen et al	12
5	Sakamoto et al	18.3
6	Karamlou et al	40
7	Hörer et al	14
8	Current study	9

- In our study we found that patients have got good surgical outcome. The mortality in our study was 9% which is comparable to the other studies on isolated TAPVC.18 out of total 20 mortalities were early mortalities, all patients <1 year of age. Sudden cardiac death and PAH crisis were the major causes of death. Most of the mortality were in the period when both sildenafil infusion and Nitric oxide were unavailable in the ICU.

CONCLUSION

Total anomalous pulmonary venous connection (TAPVC) continues to remain the most common cause for emergency surgery in congenital heart surgery units world over. With the advent of early diagnosis, better surgical practices and use of pulmonary vasodilators both early and late surgical results have improved.

Presence of pulmonary venous obstruction is the single most important factor determining the overall survival. Weight less than 3 kilograms affects the early postoperative outcomes, but has no effect on over all survival. Primary sutureless technique for repair of TAPVC provides no additional benefit over the conventional technique in both early and late outcomes.

LIMITATIONS

1.The retrospective nature of the study.

2. The Pulmonary vein score has not been included as part of analysis as it has not been recorded in all patients.

3. Longer follow up duration would give a better picture of the need for reintervention.

REFERENCES

1. Jonas RA. COMPREHENSIVE SURGICAL MANAGEMENT OF CONGENITAL HEART DISEASE. :704.

2. Fu C-M, Wang J-K, Lu C-W, Chiu S-N, Lin M-T, Chen C-A, et al. Total Anomalous Pulmonary Venous Connection: 15 Years' Experience of a Tertiary Care Center in Taiwan. Pediatr Neonatol [Internet]. 2012 Jun [cited 2020 Mar 31];53(3):164–70. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1875957212000526

3. Reardon MJ, Ott DA, Sweeney MS. Total Anomalous Pulmonary Venous Return: Report of 201 Patients Treated Surgically. Tex Heart Inst J. 1985;12(2):11.

4. Morales DLS, Braud BE, Booth JH, Graves DE, Heinle JS, McKenzie ED, et al. Heterotaxy Patients With Total Anomalous Pulmonary Venous Return: Improving Surgical Results. Ann Thorac Surg [Internet]. 2006 Nov [cited 2020 Aug 6];82(5):1621–8. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0003497506010393

5. Choudhary SK, Bhan A, Sharma R, Mathur A, Airan B, Saxena A, et al. Repair of total anomalous pulmonary venous connection in infancy: experience from a developing country. Ann Thorac Surg [Internet]. 1999 Jul [cited 2020 Apr 1];68(1):155–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0003497599003756

6. Shi G, Zhu Z, Chen J, Ou Y, Hong H, Nie Z, et al. Total Anomalous Pulmonary Venous Connection: The Current Management Strategies in a Pediatric Cohort of 768 Patients. Circulation [Internet]. 2017 Jan 3 [cited 2020 Apr 1];135(1):48–58. Available from: https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.116.023889

7. White BR, Ho DY, Faerber JA, Katcoff H, Glatz AC, Mascio CE, et al. Repair of Total Anomalous Pulmonary Venous Connection: Risk Factors for Postoperative Obstruction. Ann Thorac Surg [Internet]. 2019 Jul [cited 2020 Aug 5];108(1):122–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0003497519303546

8. Anderson RH, editor. Paediatric cardiology: expert consult activate at expertconsult.com, searchable full text online. 3. ed. Philadelphia, Pa: Elsevier, Churchill Livingstone; 2010. 1327 p. (An expert consult title - online + print).

9. Stark J, De Leval M, Tsang VT. Surgery for congenital heart defects. Chichester; Hoboken, NJ: J. Wiley & Sons; 2006.

10. Kao C-C, Hsieh C-C, Cheng P-J, Chiang C-H, Huang S-Y. Total Anomalous Pulmonary Venous Connection: From Embryology to a Prenatal Ultrasound Diagnostic Update. J Med Ultrasound [Internet]. 2017 [cited 2020 Aug 6];25(3):130–7. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6029298/

11. Primary pulmonary vein stenosis: The impact of sutureless repair on survival | Elsevier Enhanced Reader [Internet]. [cited 2020 Aug 6]. Available from:

https://reader.elsevier.com/reader/sd/pii/S0022522310014340?token=AAF60E969BA8479E563A86C65E15C0663AB362B2D31E8A9847D1C2D9504A55BC9F5293096749674B9816274F89E10027

12. Rudolph AM. Congenital diseases of the heart: clinical-physiological considerations. 2009.

13. Yun SW. Congenital heart disease in the newborn requiring early intervention. Korean J Pediatr [Internet]. 2011 [cited 2020 Aug 6];54(5):183. Available from: http://kjp.or.kr/journal/view.php?doi=10.3345/kjp.2011.54.5.183

14. Kelle AM, Backer CL, Gossett JG, Kaushal S, Mavroudis C. Total anomalous pulmonary venous connection: Results of surgical repair of 100 patients at a single institution. J Thorac Cardiovasc Surg [Internet]. 2010 Jun [cited 2020 Aug 6];139(6):1387-1394.e3. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0022522310001686

15. Bellinger DC, Jonas RA, Rappaport LA, Wypij D, Wernovsky G, Kuban KCK, et al. Developmental and Neurologic Status of Children after Heart Surgery with Hypothermic Circulatory Arrest or Low-Flow Cardiopulmonary Bypass. N Engl J Med [Internet]. 1995 Mar 2 [cited 2020 Aug 6];332(9):549–55. Available from: http://www.nejm.org/doi/abs/10.1056/NEJM199503023320901

16. Mavroudis C, Backer CL. Retrocardiac Repair of Total Anolna]ous Puhnonary Venous Connection. :12.

17. Liufu R, Shi G, Zhu F, Guan Y, Lu Z, Chen W, et al. Superior Approach for Supracardiac Total Anomalous Pulmonary Venous Connection. Ann Thorac Surg [Internet]. 2018 May [cited 2020 Aug 6];105(5):1429–35. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0003497518301723

18. Valiathan MS. Sree Chitra Tirunal Institute for Medical Sciences and Technology. Artif Organs [Internet]. 1984 May [cited 2020 Aug 6];8(2):232–3. Available from: http://doi.wiley.com/10.1111/j.1525-1594.1984.tb04280.x

19. Koshy S, Kumar RK, Gururaja RS, Shivaprakasha K. Novel Repair for Obstructed Total Anomalous Pulmonary Venous Connection to Coronary Sinus. Ann Thorac Surg [Internet]. 2005 Feb [cited 2020 Aug 6];79(2):711–3. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0003497503020903

20. Garg P, Talwar S, Rajashekar P, Saxena A, Airan B. Repair of total anomalous pulmonary venous return to the coronary sinus. Asian Cardiovasc Thorac Ann [Internet]. 2012 Apr [cited 2020 Aug 6];20(2):221–4. Available from: http://journals.sagepub.com/doi/10.1177/0218492311435513

21. Lacour-Gayet F, Zoghbi J, Serraf AE, Belli E, Piot D, Rey C, et al. Surgical management of progressive pulmonary venous obstruction after repair of total anomalous pulmonary venous connection. J Thorac Cardiovasc Surg [Internet]. 1999 Apr [cited 2020 Aug 5];117(4):679–87. Available from:

https://linkinghub.elsevier.com/retrieve/pii/S0022522399702874

22. Ricci M. Management of pulmonary venous obstruction after correction of TAPVC: risk factors for adverse outcome. Eur J Cardiothorac Surg [Internet]. 2003 Jul [cited 2020 Aug 5];24(1):28–36. Available from: https://academic.oup.com/ejcts/article-lookup/doi/10.1016/S1010-7940(03)00180-5

23. Gaies MG, Jeffries HE, Niebler RA, Pasquali SK, Donohue JE, Yu S, et al. Vasoactive-Inotropic Score Is Associated With Outcome After Infant Cardiac Surgery: An Analysis From the Pediatric Cardiac Critical Care Consortium and Virtual PICU System Registries*. Pediatr Crit Care Med [Internet]. 2014 Jul [cited 2020 Jul 11];15(6):529–37. Available from: http://journals.lww.com/00130478-201407000-00004

24. Wu Y, Wu Z, Zheng J, Li Y, Zhou Y, Kuang H, et al. Sutureless technique versus conventional surgery in the primary treatment of total anomalous pulmonary venous connection: a systematic review and meta-analysis. J Cardiothorac Surg [Internet]. 2018 Dec [cited 2020 Aug 5];13(1):69. Available from: https://cardiothoracicsurgery.biomedcentral.com/articles/10.1186/s13019-018-0756-z

APPENDIX

TAPVC	-	Total Anomalous Pulmonary Venous Connection
PAH	-	Pulmonary Arterial Hypertension
PA CRISIS.	-	Pulmonary arterial crisis
TCA	-	Total Circulatory Arrest
CPB.	-	Cardio Pulmonary Bypass
SCTIMST.	-	Sree Chitra Thirunal Institute For Medical Sciences and Technology

OBSERVATION CHART

PATIENT`S DEMOGRAPHICS

SERIAL NUMBER	
AGE AT OPERATION	
YEAR OF OPERATION	
WEIGHT OF THE PATIENT(kg)	
GENDER (M/F)	

PRE OPERATIVE ECHO PARAMETERS

TYPE OF TAPVC(SUPRACARDIAC/CARDIAC/INFRACARDIAC/MIXED)	
OBSTRUCTED/UNOBSTRUCTED	
PULMONARY ARTERIAL HYPERTENSION SEVERITY(MILD/MODERATE/SEVERE)	
ADDITIONAL CARDIAC LESIONS	

CARDIOPULMONARY BYPASS RELATED PARAMETERS

PH BEFORE BYPASS- PH <7.35 (Y/N)-	
CLAMP TIME(MIN)	
BYPASS TIME(MIN)	
TEMPERATURE - MILD/MODERATE /SEVER HYPOTHERMIA -	

TCA(TOTAL CIRCULATORY ARREST) Y/N- TCA TIME(MIN)-	
SURGERY PERFORMED	
POST CORRECTION PULMONARY ARTERIAL PRESSURES(mm Hg)	

POST OPERATIVE OUTCOMES

INOTROPIC SCORE AFTER 24 HOURS IN ICU	
NUMBER OF ICU DAYS	
PA (PULMONARY ARTERIAL)CRISIS (Y/N)	
ARRHYTHMIA AND TYPE	
PULMONARY HEMORRHAGE	
DELAYED STERNAL CLOSURE	
MORTALITY (EARLY OR LATE)- CAUSE-	

REOPERATIONS AND CAUSE-

FOLLOW UP (ECHOCARDIOGRAPHIC PARAMETERS)
PULMONARY VEIN STATUS AND FLOW)-LAMINAR/TURBULENT
ANY OTHER SIGNIFICANT FINDING-

SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES & TECHNOLOGY
THIRUVANANTHAPURAM—695 011, INDIA.
(An Institute of National Importance under Govt.of India)
Phone—(91)0471—2443152 Fax—(91)0471—2446433, 2550728, Grams—Chitramet
email : sct@sctimst.ac.in Web site—www.sctimst.ac.in

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THIRUVANANTHAPURAM-695011.

INSTITUTIONAL ETHICS COMMITTEE (IEC) MEETING
(IEC Regn No. ECR/189/Inst/KL/2013/RR-16)

SCT/IEC/1550 /AUGUST-2020 17.08.2020

Dr. Shivang Saxena
Resident, Department of CVTS
SCTIMST, Thiruvananthapuram

Dear Dr.Shivang Saxena,

The Institutional Ethics Committee reviewed and discussed your application to conduct the study entitled "**OUTCOME OF TOTAL CORRECTION FOR ISOLATED TOTAL ANOMALOUS PULMONARY VENOUS CONNECTION: A RETROSPECTIVE STUDY** (IEC/ 1550)"on July 10-17, 2020.

The following documents were reviewed:

Original documents

1. *Covering Letter addressed to the Chairperson, IEC, SCTIMST dated 08.07.2020*
2. *Covering Letter addressed to The Technical Advisory Committee, SCTIMST dated 10.03.2020*
3. *Project Proposal*
4. *Dean's signature form*
5. *Proforma*
6. *Telephone Recruitment Script in Malayalam*
7. *Telephone Recruitment Script in English*
8. *TAC Approval Letter*
9. *IEC Application Form*
10. *Declaration Form*

Revised documents

IEC feedback letter dated August 1 2020
Covering letter from Dr.Shivang Saxena addressed to Chairperson, IEC, SCTIMST dated August 1 2020
Coverletter addressed to TAC dated March 10 2020
Study proposal
TAC-Clinical studies clearance with comments and responses
IEC Application form
Revised Telephone recruitment script in English
Revised Telephone recruitment script in Malayalam
Proforma
CV of PI, Dr.Shivang Saxena with MCI Registration
CV of Co-PI Dr.Sabarinath Menon with Kerala Registration
CV of Co-PI Dr.Baiju Dharan with TCMC Registration
CV of Co-PI Dr.Sudip Dutta Baruah with Assam Medical Council Registration
CV of Co-PI Dr.Sowyma Ramanan with TCMC Registration
CV of Co-PI Dr.Deepa Sasikumar with TCMC Registration

The following members of the Ethics Committee were present at the meeting held onJuly 10-17, 2020 at the offices and residences of the members

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Dr. R V G Menon	M Tech, PhD	Male	Lay Person (Chairman)	No
2.	Dr. Rema M. N	MD	Female	Basic Medical Scientist	No
3.	Dr. Kala Kesavan. P	MBBS, MD	Female	Basic Medical Scientist	No
4.	Smt. Sathi Nair	MA (English Literature)	Female	Lay Person	No
5.	Dr. Christina George	MD Psychiatry	Female	Clinician	No
6.	Dr. Harikrishnan S	MD, DM (Cardiology) DNB (Cardiology)	Male	Clinician	Yes
7.	Dr. Mala Ramanathan	PhD	Female	Social Scientist (Member Secretary)	Yes

IEC Decision

The IEC approved the conduct of the study in the present form.

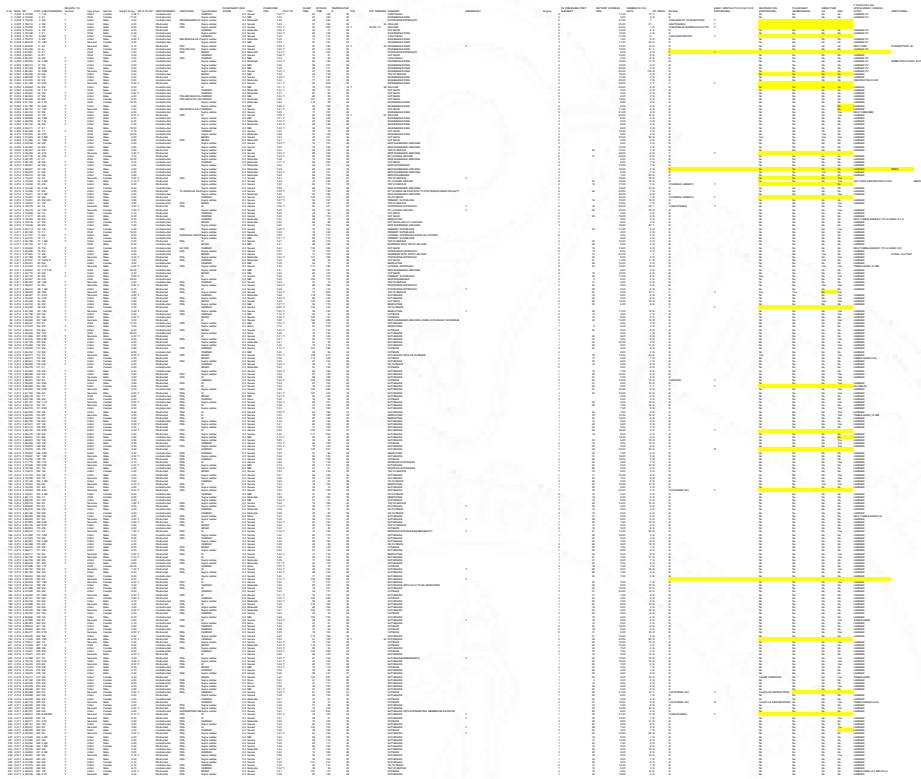
Remarks:
The Institutional Ethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and asks to be provided a copy of the final report.

There was no member of the study team who participated in voting / decision making process. The ethics committee is organized and operated according to the requirements of Good Clinical Practice and the requirements of the Indian Council of Medical Research (ICMR).

Sincerely,

Mala Ramanathan
Member Secretary, IEC

MASTER CHART



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