ROLE OF 128 SLICE MULTI-DETECTOR COMPUTED TOMOGRAPHY ANGIOGRAPHY IN EVAULATION OF CONGENITAL CYANOTIC HEART DISEASES - A HOSPITAL BASED ONE YEAR CROSS SECTIONAL STUDY

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7

LIST OF ABBREVIATIONS

GLOSSARY	ABBREVIATIONS
MDCT	Multidetector computed tomography
CTA	Computed tomography angiography
TTE	Transthoracic echocardiography
CCA	Cardiac catheter angiography
CCHD	Congenital cyanotic heart disease
CCHD	Congenital heart disease
TOF	Tetralogy of Fallot
TGA	Transposition of great vessels
TA	Truncus arteriosus
TAPVC	Total anomalous pulmonary venous connection
PAPVC	Partial anomalous pulmonary venous connection
ASD	Atrial septal defect
VSD	Ventricle septal defect
PDA	Patent ductus arteriosus
DORV	Double outlet right ventricle
MAPCA	Major aortopulmonary collateral arteries
PAH	Pulmonary artery hypertension
COA	Coarctation of the Aorta

SVC	Superior vena cava
PS	Pulmonary Stenosis
DSCT	Dual-source computed tomography
PPV	Positive predictive value
NPV	Negative predictive value

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ABSTRACT

Background and objectives:

Cyanotic heart disease refers to a type of congenital heart defect that causes cyanosis, a bluish discoloration of the skin and mucous membranes. This condition occurs because the heart defect allows oxygen-poor blood to mix with oxygen-rich blood, resulting in decreased oxygen levels in the bloodstream. Cyanotic heart defects often involve structural abnormalities in the heart that affect how blood flows through the heart and to the lungs.

Some most common cyanotic heart defects include:

1. Tetralogy of Fallot**:**
2. Transposition of the Great Arteries
3. Tricuspid Atresia
4. Total Anomalous Pulmonary Venous Return (TAPVR)
5. Truncus arteriosus

Cyanotic heart defects typically require surgical intervention early in life to improve blood flow and oxygenation. Surgery aims to correct the structural abnormalities or to temporarily improve blood flow until definitive repair can be performed. The long-term outlook for individuals with cyanotic heart disease depends on the specific defect, the timing of intervention, and any associated complications. Advances in surgical techniques and medical management have significantly improved outcomes for many patients with these conditions.

The objective of the research was to evaluate the sensitivity, specificity, and accuracy of CT scan in detecting diverse cardiovascular abnormalities in individuals with complex congenital heart disease. It also sought to gather additional information for pre-operative patients with inconclusive results on echocardiography. Furthermore, the study aimed to compare the findings of multi-detector computed tomography angiography (MDCTA) with 2D-echocardiography to accurately outline the morphological characteristics of the cardiovascular system. The goal was to determine whether MDCT could potentially replace diagnostic echocardiography for assessing complex CHD.

Approach: In a prospective, comparative, single-center study, a total of 42 patients aged between 0 days and 17 years were enrolled. Pediatric cardiologists referred all patients between January 2023 and december 2023. Initial echocardiography was conducted on all patients, and final diagnosis was confirmed on CTA and all the findings correlated with echocardiography findings.

Results

We discovered that 39 (92.9%) had a 2D Echo diagnosis of CCHD, while 41 (97.6%) had a CT angiography diagnosis. TOF was the most prevalent CCHD of all. CT and ECHO incidences were 15 (35%) and 14 (33%), respectively. Additional findings from CT angiography included 5 (11.9%) with TAPVC, 4 (9.5%) with DORV and pulmonary stenosis, PAPVC, Hypoplastic Left Ventricular Syndrome, 3 (7.1%) with coarctation of the aorta and interrupted aortic arch, 2 (4.8%) with TGA, and 1 each with Truncus arteriosus and Tricuspid atresia with Ebstein's anomaly. On CT angiography, no missed diagnoses were found.

According to our research, cyanotic cardiac disease was the most frequently reported tetralogy of fallot. The inability of echocardiography to distinguish the structure of the pulmonary arteries was its primary flaw. CTA angiography provided a more accurate diagnosis of pulmonary stenosis and atresia than echocardiography did.

Congenital heart abnormalities that restrict or impede blood flow through the pulmonary arteries can result in the development of multiple pulmonary collateral arteries, or MPCAs. Six of the 14 cases with TOF in our investigation had collateral arteries present, located, sized, and running, which the echocardiogram had evidently missed. These cases were identified by CTA.

Additionally, CT angiography was essential in our investigation for the identification and characterization of these arteries, supporting clinical judgment and patient management plans.

The CTA provided a clearer picture of the presence of hypoplastic aortic arch coupled with aortic coarctation, while most patients diagnosed by echocardiography did not show these features.

Conclusions:

The overall sensitivity of the MDCT angiography for the detection of intra & extra cardiac anomalies is higher comparable to the echocardiography predominantly in pulmonary vascular anomalies, coarctation of aorta & hypoplastic aortic arch and multiple pulmonary collateral arteries. It is a highly useful tool for preoperative planning and postoperative follow-up, and it can be used as an alternative for echocardiography in complicated congestive heart failure.

INTRODUCTION

Congenital heart disorders (CHDs), which account for 1% of all live births, are the most common congenital birth defects. A grade report on hereditary heart diseases advocates that, based on the former analysis, considering a natal prevalence of CHD as 9/1000, the estimated incidence of progenies born with CHD in our India would be larger than 200,000 per year[1]. Amongst these about 1/5th are about to progress serious defects, who need an intervention in the first year of their life.[1,2]

Based on the physical examination results of cyanosis (bluish discoloration of the skin), there are two main categories of CHDs: cyanotic and acyanotic. The left half of the heart receives systemic venous blood instead of the pulmonary circulation in cyanotic CHDs. The "5 Ts" are the most significant cyanotic CHDs and comprise.[3,4,5]

- Tetralogy of Fallot
- Transposition of the great arteries (TGA) and
- Tricuspid atresia
- Total anomalous pulmonary venous connection (TAPVR).
- Truncus arteriosus

In cyanotic congenital heart disease (CCHD) there is seen blue coloring turning of the skin as usually happens in the toes, fingers, and lips.[6] Echocardiography has been the initial imaging modality for the assessment and diagnosis of CHDs. This technique is commonly operator’s dependent with observation error limited through an acoustic window.[6,7]

The gold standard method for detecting congestive heart failure (CHD) is usually traditional angiography, which has several drawbacks such as being invasive, requiring general anesthesia, and exposing newborns to radiation and iodinated contrast chemicals. [8]

Overall, the availability of advanced CT and MR technologies has certainly revolutionized cardiac diagnostics, offering safer and less invasive options for evaluating heart health and reducing the need for invasive procedures like cardiac catheterization in many cases.

One of the most reliable methods for identifying infantile congenital heart disease (CHD) is diagnostic cardiac catheter angiography, or CCA. Due to the invasive nature of the treatment, large doses of ionizing radiation, the necessity for general anesthesia, and difficulties connected to the catheter, there are certain limitations. [8’9]

The sound structure and functionality of even extra-cardiac circulation, such as the pulmonary arteries, coronaries, aorta, and systemic veins, or pulmonary, could be expressed by multidetector computed tomography (CT angiography). This would even show the pulmonary parenchyma, the airway, and those vessel walls and mediastinal anomalies. [8]

With the above knowledge, despite the advancements in imaging modalities, there remains a need to evaluate the efficacy and role of 128-slice CT angiography specifically in the evaluation of congenital cyanotic heart diseases. The objective of this research is to evaluate the overall accuracy, sensitivity, and specificity of CT angiography in the diagnosis of cardiovascular anomalies in patients with congenital cyanotic heart disorders. It also aims to investigate the usefulness of CT angiography in offering thorough anatomical data for preoperative planning and postoperative monitoring. By addressing these objectives, this research aims to contribute to the optimization of diagnostic strategies and management protocols for patients with congenital cyanotic heart diseases.

1.2 Significance of accurate evaluation in CHD management

Accurate evaluation of CHD is paramount for optimal management and outcomes. Timely diagnosis and characterization of the cardiac and extra-cardiac anatomy are essential for planning appropriate interventions, whether surgical, interventional, or medical. Furthermore, precise evaluation enables early identification of complications and facilitates targeted therapeutic strategies journey to a precise diagnosis of CHD begins with comprehensive imaging studies, which are indispensable for the detailed visualization required. Technologies such as echocardiography, cardiac magnetic resonance imaging (MRI), and CT angiography (CTA) scans have become fundamental tools in the diagnosis and ongoing management of CHD. Echocardiography, for instance, provides essential information on heart structure, function, and blood flow without radiation exposure, making it particularly useful for initial assessments and routine follow-ups. However, in cases where echocardiography is limited by acoustic windows or when more detailed images are necessary, techniques like MRI and CT scans are employed. These modalities offer superior spatial resolution and the ability to capture complex anatomical details and are especially beneficial in pre-surgical planning and in assessing the relationships of cardiac structures with surrounding tissues [34,39].

Moreover, the role of cardiac catheterization has evolved from being primarily diagnostic to more therapeutic, often used in conjunction with other imaging modalities to provide a comprehensive overview of the heart's anatomy and function.

It allows for the measurement of pressure and oxygen levels in different parts of the heart and blood vessels, which is critical in assessing the severity of the disease and planning for interventions like stent placements or balloon angioplasty. [7]

The timing of these diagnostic interventions is also crucial. Early diagnosis through prenatal screening and immediate neonatal assessment can significantly impact outcomes by allowing for prompt interventions after birth, thus preventing the progression of the disease and the onset of complications. This early intervention strategy is particularly important in severe cases of CHD, where delays can lead to detrimental outcomes such as heart failure, organ damage, and in some cases, death. [14'15]

Beyond the physical assessment, genetic testing has become increasingly relevant in understanding the etiology of congenital heart defects, which in many cases have a genetic component. Identifying genetic markers associated with CHD can not only help in diagnosing the condition but also aid in family planning and the assessment of recurrence risk in future pregnancies. [16]

The management of CHD does not end with the initial diagnosis and intervention. Long-term follow-up using these sophisticated imaging tools is essential to monitor the patient's progress, manage ongoing or emerging complications, and adjust treatment plans as necessary. This ongoing monitoring is vital, as many patients with repaired CHD can experience residual issues such as arrhythmias, heart failure, or pulmonary hypertension.

The implications of these diagnostic advancements are profound. They not only enhance the quality of care but also improve the quality of life for patients with CHD. With early and accurate diagnosis, tailored interventions, and continuous monitoring, patients can achieve be 2D echocardiography developmental outcomes and lead fuller, more active lives. This comprehensive approach to the management of CHD underscores the importance of an integrated care team that includes cardiologists, cardiac surgeons, radiologists, paediatricians, and geneticists, all working together to deliver optimal care. [17'18]

The precise evaluation of CHD is more than a diagnostic challenge; it's a critical component of holistic patient management that influences every decision in the treatment continuum. From the initial detection through to long-term care, the advancements in diagnostic technologies and methodologies have paved the way for improved survival rates and be 2D echocardiography quality of life for those affected by this complex group of diseases. As research and technology continue to advance, the prospects for those living with CHD will only improve, reinforcing the need for continued innovation and application of the best available diagnostic and management practices. [19]

AIM & OBJECTIVES

To evaluate the sensitivity, specificity, and accuracy of CT angiography in the diagnosis of congenital cyanotic heart disease in patients and to gather extra cardiac anomaly information for the purpose of organizing the treatment for the patient coming to the Radiology department of KLE's Dr. Prabhakar Kore Hospital, Belagavi.

Primary Objective

The primary objective of this project is to rigorously evaluate the diagnostic performance of the 128-slice multi-detector computed tomography CT angiography (MDCTA) in the detection of congenital cyanotic heart diseases (CCHD). Specific metrics to be assessed include:
This evaluation will help quantify the effectiveness of CT angiography compared to current standard diagnostic practices and establish its reliability and potential to replace or supplement existing diagnostic modalities.

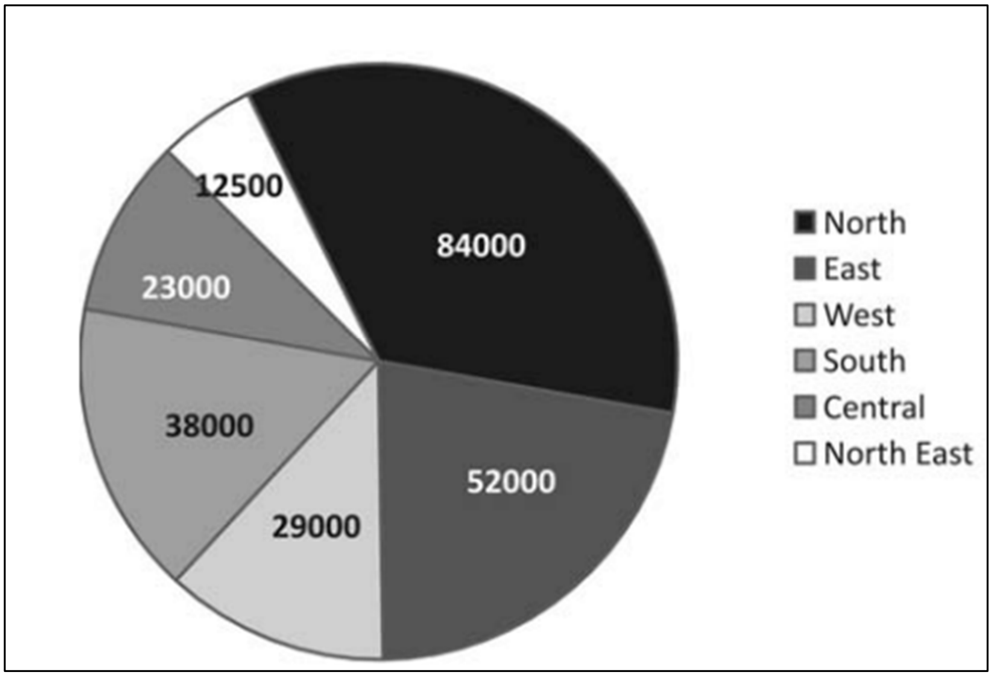
Secondary Objectives

The secondary objectives of the study are designed to correlation with 2D-echocardiography findings in both pre-operative and post-operative patients.

- To compare the findings of CT angiography with those of echocardiography, particularly focusing on the aspects where CT angiography might provide additional information or clearer imaging.

REVIEW OF LITERATURE

Congenital heart disease (CHD) is the most frequently recurrently happening congenital disorder, accountable for 28% of all reported congenital birth defects. The provincial partition of cases displays that northern part of India has pragmatic with higher prevalence of cases than any other. Uttar Pradesh, Bihar, Jharkhand and Madhya Pradesh, which apparently have much greater CHD burden as compared to the rest of states, have coped much worse.[10'11]



Graph 1.- Pie chart for prevalence of cases in India

Taleb AA et al had analysed Out of the 50 newborns with CCHD diagnoses, 39 (78%) had a M/F ratio of 3.55:1. At presentation, the average age was 11.78 ± 9.4 days. In our NICU group, the frequency of CCHD was reported to be 9.5% (50/524). D-transposition of the great arteries (D-TGA) accounted for 66% of all cases of CCHD, with complex CCHD (12%), hypoplastic left heart syndrome (HLHS) (12%), and hypoplastic right ventricle (2%), being the least prevalent types.[11]

Kapoor R et al in their epidemiology data seen the prevalence of 26.4 per 1000 patients. VSD (ventricular septal defect) was the mutual lesion (21.3%), followed by ASD (atrial septal defect) in 18.9% and PDA (patent ductus arteriosus) in 14. 6%. Tetralogy of Fallot was the frequent cyanotic heart disease (4.6%). Supreme number of children with heart disease (82.9%) were diagnosed between 0-3 years of age.[12]

Chaudhary A et al studied 150 patients aged under 5 years presenting with signs and symptoms expressive of CHD were evaluated in this study. 91 were found to have congenital heart disease. VSD in 31.87%, ASD in 29.98%, PDA in 9.9% TOF in 5.49% and complex heart diseases in 16.48%cases. The more number of cases (46.15%) in 1 to 12 months of age, 37.37% cases in neonatal period,16.48% cases there in were of 1 to the 5 years of age. In them the most common at the time features were difficulty in breathing, followed by feeding difficulty.[13]

A VIEW OF CONGENITAL HEART DISEASE[15,16]

The CHDs are mainly due to the following conditions;

1. Malpositions of Heart Dextrocardia may be accompanied by situs inversus

2. Shunts (Cyanotic CHD)

3. Obstructions (Obstructive CHD)

OBSTRUCTIONS

1. Coarctation of Aorta 5-7%

2. Aortic stenosis and atresia 4-6%

3. Pulmonary stenosis and atresia 5- 7%

SHUNTS

A. Left to Right shunts (Acyanotic or Late Cyanotic group) cyanosis months or years after birth [17,18,19]

1. Ventricular septal defect (VSD) -25-30%

2. Atrial septal defect (ASD)- 10-15%

3. Patent ductus arteriosus (PDA)- 10-20%

B. Right to Left shunts (Cyanotic group) [20,21,22]

1. Tetralogy of Fallot (TOF)- 6-15%

2. Transposition of great arteries -4-10%

3. Persistent truncus arteriosus – 2%

4. Tricuspid atresia and stenosis 1%

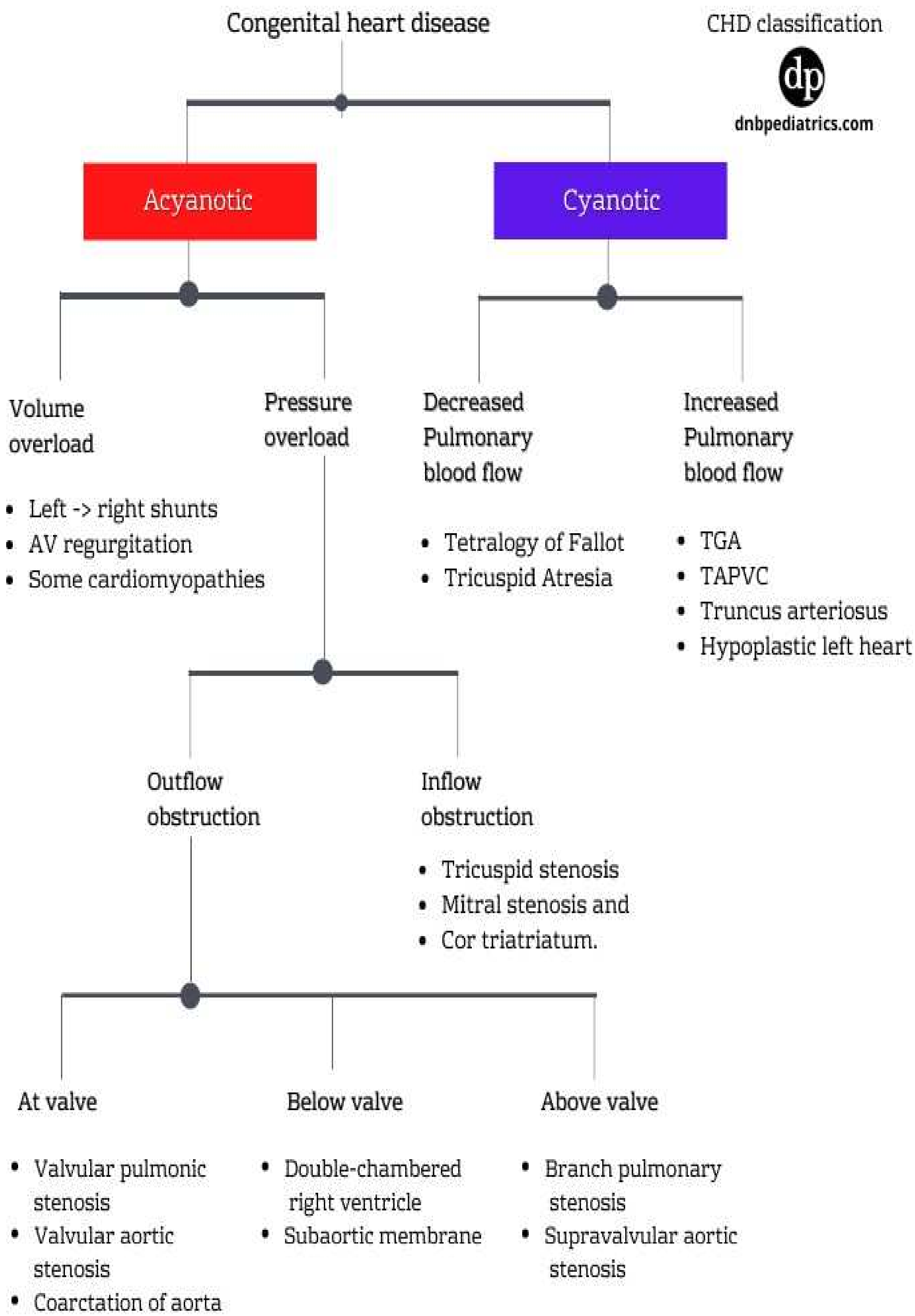


Table 1: Classification of congenital heart diseases

- **Tetralogy of Fallot:** Tetralogy of Fallot (TOF) as seen above, is the most common cyanotic hereditary heart disease, on behalf of 5% to 7% of all known type CHDs. TOF is a conotruncal cardiac defect categorized by a large and anteriorly mal-aligned ventricular with septal defect, an overriding of the aortic root, and even narrowing of the sub pulmonary and also pulmonary valves. Right ventricular with hypertrophy is subordinate to the obstacle in the right ventricular tract depletion and pulmonary valve as well.[21,22]

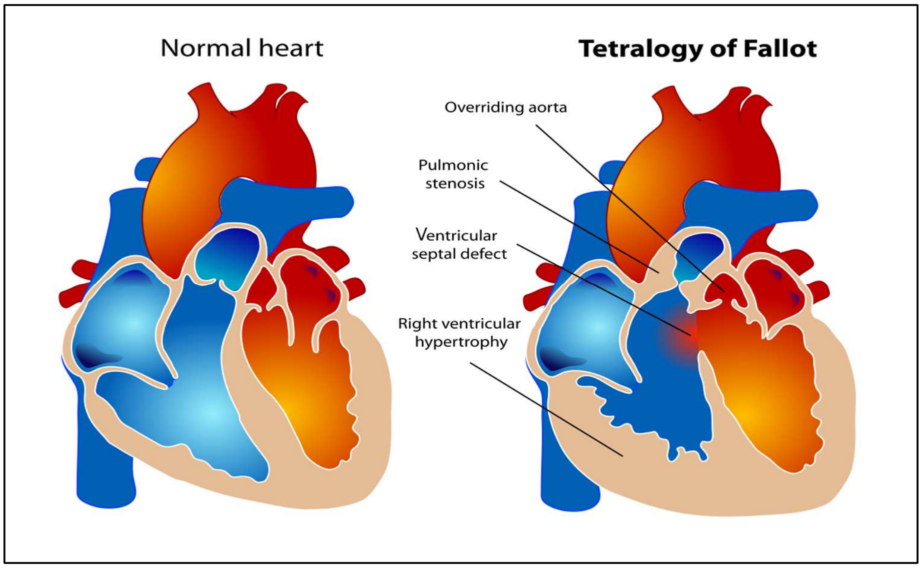


FIGURE 1 : DIAGRAMMATIC REPRESENTATION OF NORMAL VS TETRALOGY OF FALLOT

- **Transposition of great arteries:** TGA is a childhood cardiac congenital defect rising from an embryological discord between the major vessel aorta and other bigger vessel pulmonary trunk. During development of heart, the conotruncal, the dividing septum helixes near the aortic sac thus separating the truncus arteriosus into the pulmonary and separated aortic networks. These channels then developed as pulmonary arteries and aorta, correspondingly. TGA befalls when the conotruncal septum flops to trail/track its spiral course and rather it led to linear orientations. Accordingly, the aorta ascends as of the right ventricle and the pulmonary trunk get up from the left ventricle. The greatest commonest formed of TGA is referred to as dextro-TGA (D-TGA).[23,24,25,26]

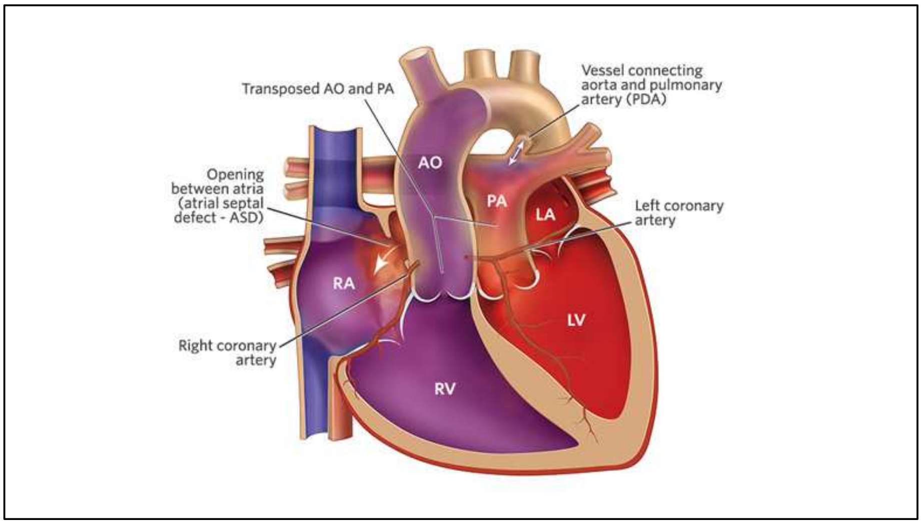


FIGURE 2 : DIAGRAMMATIC REPRESENTATION OF TRANSPOSITION OF GREAT ARTERIES

- **Persistent truncus arteriosus:** Truncus arteriosus is a occasional, inherited, cyanotic cardiac incongruity considered the defects with ventricular septal defect (VSD), common ventricular outflowing tract and a single truncal valve. Systemically and pulmonary venous blooding mixed at the VSD and desaturating blood is ejecting into the outflow tract. The pulmonary arisen arteries will be directly from the truncus. Thus, pulmonary vascular resistance (PVR) regulates the quantity of pulmonary blood flow (PBF). Death in beginning is probable short of surgical involvement.[27,28]

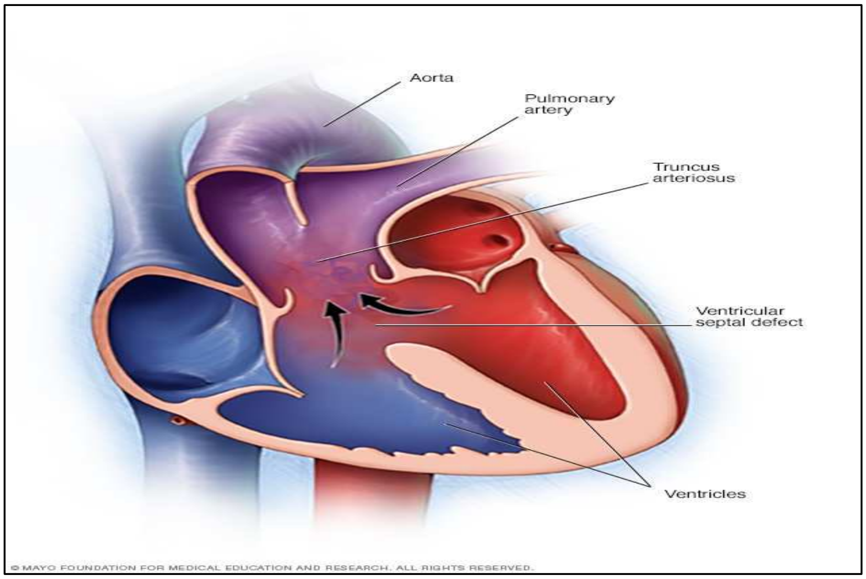


FIGURE 3 : DIAGRAMMATIC REPRESENTATION OF PERSISTENT TRUNCUS ARTERIOSUS

- **Tricuspid atresia:** A cyanotic congenital heart flaw featuring with the complete absence in formation of the tricuspid valve itself. Therefore, the nonappearance of communication among the right atrium and the ventricle leading to cyanosis. This situation will have various subtypes with wide-ranging clinical appearances determined by the degree of pulmonary blood flow.[29,30,31]

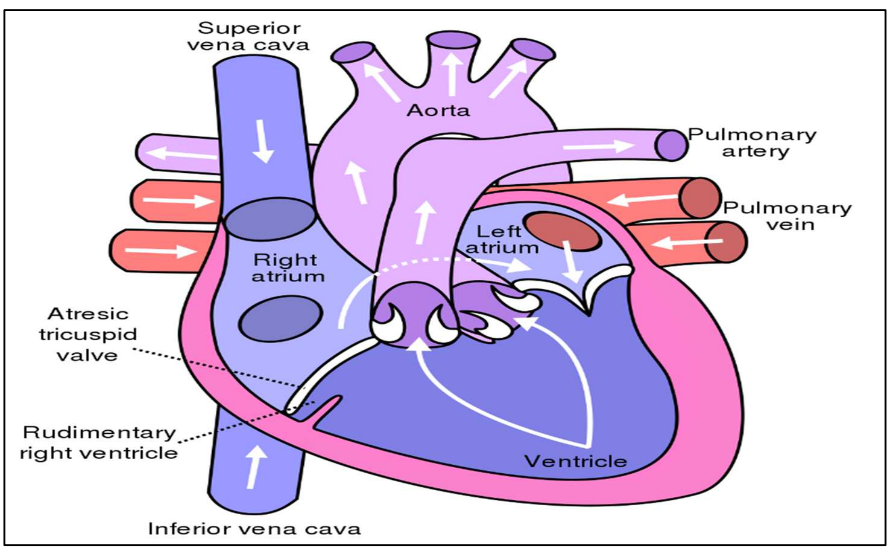


FIGURE 4 : DIAGRAMMATIC REPRESENTATION OF TRICUSPID ATRESIA

- **Total anomalous pulmonary venous connection (TAPVC) :** is a congenital heart defect where the pulmonary veins, which carry oxygen-rich blood from the lungs, connect abnormally to the heart or nearby blood vessels instead of the left atrium. This condition leads to poor oxygenation of blood, causing symptoms like cyanosis and difficulty breathing in newborns. Diagnosis is typically made through echocardiography, and surgical repair is necessary to redirect the veins to the correct connection. Early intervention improves outcomes significantly for affected children. [31,45]

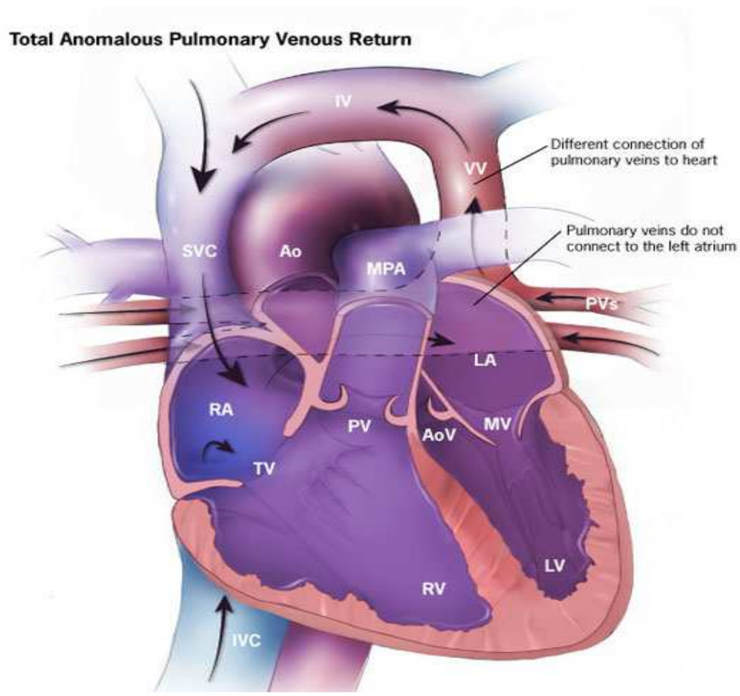


FIGURE 5 : DIAGRAMMATIC REPRESENTATION OF TOTAL ANOMALOUS PULMONARY VENOUS CONNECTION (TAPVC)

Increased Pulmonary Vascularity	**Decreased Pulmonary Vascularity**
Total anomalous pulmonary venous connection (TAPVC)	Tetralogy of Fallot
Truncus arteriosus	Tricuspid atresia
Transposition of great arteries	Pulmonary atresia
Single ventricle	Pulmonary stenosis and atrial septic defect
Double outlet right ventricle	Ebstein anomaly

Table 2 : By Singh SP et al on the types of CCHD[32]

2.2 EVALUATION FOR CONGENITAL HEART DISEASES

a) Fetal Echocardiogram

On of the safest modality of examination could be performed in all fetuses who are either at greater the risk or already the supposed cases of cardiac aberration if noted on obstetric/gestational ultrasound. [34]

b) Pulse Oximetry Screening

In 2011, the American Academy of Pediatrics and the Uniform Screening Panel in the United States both advised pulse oximetry screening for congenital cardiomyopathy (CCHD) in newborns in 2012. [6]

Only the identification of cardiac lesions with cyanosis and a right to left shunt benefited from this. Screening the right hand and either foot is recommended. The subsequent circumstances were considered abnormal:

- Oxygen Saturation <90%
- • An hour-long time interval between three readings showing a variation in oxygen saturation of more than 3% between the right hand and foot;
- <95% Oxygen saturation in both hands/ feet on three measurements, separated by an hour

c) Hyperoxia Test

The hyperoxia test helps distinguish between congenital heart disease (CCHD) and pulmonary disease in newborns. It involves measuring arterial blood gases initially on room air and after 10 minutes of breathing 100% oxygen. In CCHD, the PaO2 typically does not rise significantly with 100% oxygen, indicating circulatory issues. In pulmonary disease, PaO2 usually increases above 100 mm Hg, indicating lung-related problems. This test guides prompt diagnosis and treatment decisions in neonates presenting with cyanosis. [39]

d) Electrocardiogram (ECG)

ECG identifies only the rhythm abnormalities, auricular or ventricular hypertrophy, dextrocardias, or abnormal axis deviation.[36]

e) Chest radiography

It can show the flow of blood in the lungs is normal, increasing, or diminished. able to recognize particular unusual features of CCHD, such as the excessive cardiomegaly in Ebstein's anomaly, the "boot-shaped" heart in TOF, the "snowman" in total anomalous venous circulation, and the "egg-shaped" heart observed in transposition of great arteries. further useful in distinguishing between cardiac and pulmonary diseases.[37,38,39]

f) Two-Dimensional Echocardiography

The gold standard non-invasive test for identifying CHD. The gradient of outflow tract blockage and the degree and direction of the shunt can be ascertained by echocardiography using Doppler technology. [36,40]

g) Advance Imaging

Advance investigation includes cardiac catheterization angiography, magnetic resonance imaging (MRI), and computed tomography for be2D echocardiography visualization the structure of the heart prior to heart surgery.[39,40]

h) Invasive cardiac angiography

Gold standard and plays a important tool in the comprehensive evaluation of congenital heart disease (CHD), providing detailed anatomical and hemodynamic information essential for treatment planning. Invasive angiography detailed visualization of cardiac structures and precise hemodynamic measurements are required. [39]

i) Comparison of Echocardiography, Cardiac Catheter angiography (CCA), and Multi-Detector Computed Tomography (CT angiography)

Echocardiography, Cardiac Catheter angiography, and CT angiography are the three main imaging modalities used in the evaluation of CHDs, each with its own strengths and limitations. Echocardiography is widely employed due to its non-invasiveness and ability to provide detailed real-time imaging of cardiac morphology and function. However, it is limited by factors such as operator dependence and suboptimal visualization of certain structures. CCA, although considered the gold standard for CHD diagnosis, is invasive and associated with risks such as catheter-related complications and ionizing radiation exposure. CT angiography offers high-resolution imaging of both cardiac and extra-cardiac structures in a non-invasive manner, making it an attractive alternative to CCA. This section provides a comparative analysis of these three modalities in terms of their diagnostic accuracy, safety, and practicality in CHD evaluation. [9,39,44]

Coronary CT angiography	**Coronary angiography**	**ECHO**
Non-Invasive	Invasive	Non-Invasive
Outpatient visit	Require day care admission	Outpatient visit
iodine contrast	iodine contrast	No iodine contrast
Resume normal activity	Resume normal activity after 24 hours right after scanning	Resume normal activity
Risk: safer	Risk: death, stroke, CA • dissection about 1:1000	Safe
Gold standard	More emerging technique	First line of investigation

Table 3: Comparison of Multi-Detector Computed Tomography (CT angiography) Cardiac Catheter angiography (CCA), and Echocardiography,

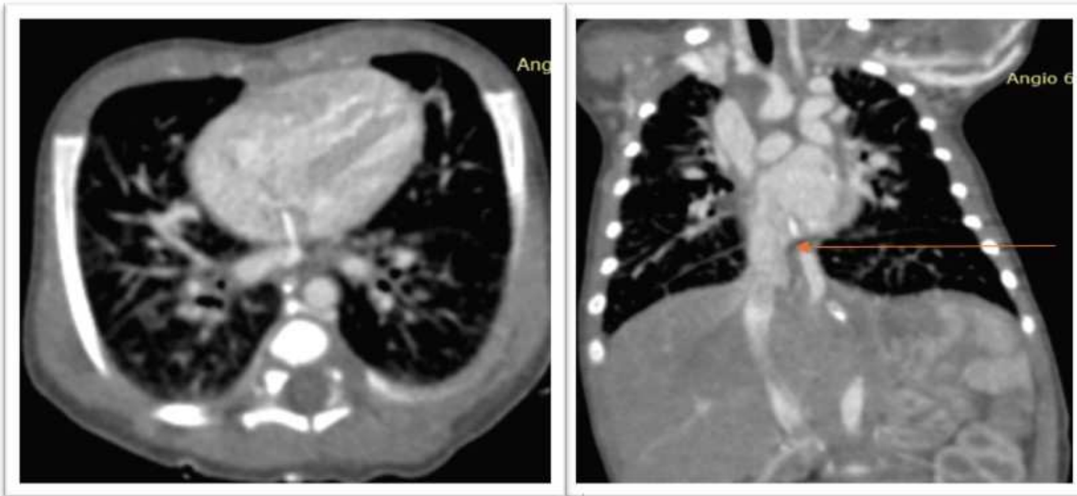


FIGURE 6 : AXIAL & CORONAL CT PULMONARY ANGIOGRAPHY SHOWING BILATERAL INFERIOR PULMONARY VEINS DRAINING INTO VERTICAL VEIN FURTHER DRAINING INTO INFERIOR VENACAVA SUGGESTING- INFRACARDIAC TOTAL ANOMALOUS PULMONARY VENOUS CONNECTION

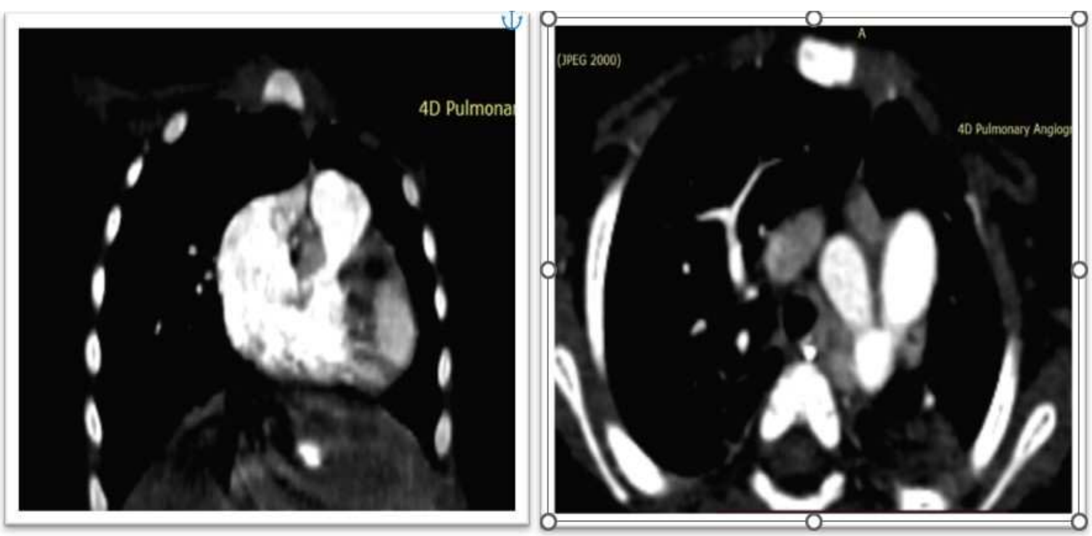


FIGURE 7 : CORONAL & AXIAL CT PULOMANRY ANGIOGRAPHY SHOWING VSD WITH PULMONARY STENOSIS, RIGHT VENTRICULAR HYPERTROPHY SUGGESTING- TETROLOGY OF FALLOT WITH LARGE PATENT DUCTUS

CT IMAGING FOR CONGENITAL CYANOTIC HEART DISEASES

2.3 CT IMAGING FOR CONGENITAL CYANOTIC HEART DISEASES

Multidetector computed tomography is a valuable and efficient imaging technique for evaluating congenital heart disease. Unlike invasive procedures like cardiac catheterization and to some extent cardiac MRI, CT angiography provides rapid and non-invasive assessment. [39]

Unlike conventional CT scans, CT angiography specifically tailored for congenital heart disease evaluation requires interpretation on a fully equipped workstation. This workstation enables detailed multiplanar 2D and 3D analysis, facilitating comprehensive evaluation of cardiac structures and abnormalities. This capability ensures accurate diagnosis and treatment planning based on detailed imaging data.[42]

Cardiac multidetector computed tomography offers several advantages for evaluating congenital heart disease. It provides faster scanning with high speed and extensive anatomic coverage, all while minimizing radiation exposure. The technology includes flexible ECG-synchronized imaging, crucial for enhancing image quality and reducing patient risk.

Current CT angiography methods excel in accurately assessing extracardiac structures such as lungs, great vessels, and airways. They also provide clear visualization and detailed descriptions of coronary arteries and intracardiac structures. Radiologists conducting cardiac CT angiography in children must be proficient in optimal scan procedures and interpreting typical cardiac CT imaging findings. [43]

Compared to cardiac MRI, cardiac CT scanning offers advantages in evaluating both right and left ventricular capacities. These include rapid data acquisition during a single breath-hold, shorter imaging times, and superior spatial and contrast resolutions. These factors facilitate easier and faster segmentation of cardiac structures. However, cardiac MRI generally provides be2D echocardiography temporal resolution compared to cardiac CT scans. [44]

Overall, the choice between cardiac CT angiography and cardiac MRI depends on the specific clinical scenario, balancing factors such as temporal resolution needs, imaging duration, and the detail required for comprehensive diagnosis and treatment planning in congenital heart disease [44,45]

ECG-synchronized CT scans are increasingly utilized in the modern era for four-dimensional (4D) assessment of conotruncal anomalies across the cardiac cycle, particularly when these anomalies are suspected based on clinical examination. Similar to coronary CT angiography, the optimal cardiac phase for ECG-synchronized cardiac CT scans in these cases should be carefully selected based on heart rate and clinical recommendations.

For anatomical evaluations, the choice typically revolves around targeting a specific cardiac phase: In patients with high heart rates (>75 beats per minute), the end-systolic phase is often selected due to its shorter duration and reduced motion artifact.

Conversely, in patients with low heart rates (<50 beats per minute), the mid-diastolic phase is preferred for its greater temporal resolution and clearer depiction of structures during diastole. This targeted approach ensures that ECG-synchronized CT scans provide detailed and accurate imaging of conotruncal anomalies throughout the cardiac cycle, optimizing diagnostic accuracy and aiding in effective clinical management. [44,45,46]

To achieve high-quality cardiac CT scans in paediatric patients, it's essential to use polyphase or dual-phase acquisition, capturing both end-systolic and end-diastolic phases. Placing ECG leads outside the scan range helps reduce metallic artifacts on images. Optimizing scanning parameters tailored to paediatric patients, such as tube settings and contrast dosage, improves image clarity. Controlling motion with sedation, when necessary, minimizes artifacts, ensuring accurate evaluation of cardiac anatomy and conditions. [44]

- - The first step in designing a CT scanning structure should be to minimize gesture artifacts by allocating the maximum through gantry rotation time. Dual-source CT scanning systems, on the other hand, provide the highest temporal resolution (i.e., 75–83 milliseconds), which is comparable to a portion of a 360-rotation period. -Another is that, in order to achieve higher-quality multiplanar reforma2D echocardiography images, axial CT scan imageries should be reproduced using as thin as possible reconstructed sections that would overlap at least roughly 50% (such as 0.6 mm sections or 0.3 mm reconstruction intermissions). heart CT scan images in two dimensions (2D) and three dimensions (3D).

- Third: By using twofold selection in the z-direction, the z-flying focus spot of technology can reduce windmill artifacts caused by the geometrical aspect of the CT angiography cone beam and increase longitudinal spatial resolutions by a factor of about 1.4.

Lastly, an iterative reconstruction kernel or a 3D adaptive noise-diminishing filter may be used to lessen the picture sound on a cardiac CT scan.

- With 64-detector row CT angiography scanners, the maximum anatomic exposure appears to almost completely saturate the image quality. Additionally, spiral scanning may be replaced by sequential scanning using the most recent 320-CT angiography scanners, which have a 16-cm z-axis reporting. The 128-slice CT now has more detectors, indicating a greater volume coverage and faster scan times. Alternatively, the low-tube that already exists with appropriate photos.[45]

Mangal R et al studies a prospective, comparative, single-centre study, 50 patients aged 6 days to 17 years were examined using a Siemens SOMATOM Definition AS+ 128-slice CT scanner. Scans were conducted from the thoracic inlet to the L1-L2 level with detector collimation set at 28 x 0.6 mm. Slice thickness was maintained at 3 mm. Contrast medium, a non-ionic solution at 320 mg/ml concentration, was administered intravenously at 2 ml/kg with a flow rate of 2-3 ml/sec. For enhanced anatomical detail, at least two phases were captured per patient. The specific region of interest varied depending on the study type; for instance, image acquisition was synchronized with contrast enhancement in the ascending aorta when imaging the aorta, such as in cases involving surgical shunts or coarctation of the aorta..

Collimation of the detector was 28 x 0.6 mm. The slice has a 3 mm thickness. Non-ionic contrast media with a dosage of 320 mg/ml and a flow rate of 2-3 ml/sec was used. For more anatomical information, at least two phases were recorded for every subject. The focus area differed depending on the kind of investigation. We employed contrast enhancement imaging in the ascending aorta to get images of the aorta in patients who had aortic coarctation or surgical shunts. They found that, in contrast, The CT angiography is just as effective as CCA in They activated scanning of the left or right pulmonary arteries or the major pulmonary artery when evaluating the pulmonary vasculature. When dealing with intracardiac shunts, the procedure is more difficult. mage acquisition was triggered off the right atrium for suspected right-to-left shunts and off the left atrium for suspected left-to-right shunts. The study identified a total of 177 cardiovascular anomalies, including three cases of ventricular septal defects (VSD) and one atrial septal defect (ASD) that were missed on CT angiography. The overall efficacy of CT compared to catheter angiography was reported to be 97.1%, indicating high accuracy in diagnosing cardiovascular abnormalities in this cohort of patients.

In a study involving 50 patients, several anomalies were identified, including three cases of ventricular septal defect (VSD) and one case of atrial septal defect (ASD) that were missed on CT angiography. Overall, the combined accuracy of CT angiography compared to catheter angiography was approximately 97.1%.

CT angiography demonstrated high accuracy in evaluating various congenital heart defects such as Tetralogy of Fallot (TOF), Double Outlet Right Ventricle (DORV), Total Anomalous Pulmonary Venous Connection (TAPVC), Transposition of the Great Arteries (TGA), Coarctation of the Aorta (COA), right-sided aortic arch, Partial Anomalous Pulmonary Venous Connection (PAPVC), persistent superior vena cava (SVC), Patent Ductus Arteriosus (PDA), Pulmonary Stenosis (PS), vascular sling, and coronary cameral fistula, with accuracies reported as percentages. While CT angiography was comparable to catheter angiography in diagnosing extracardiac vascular anomalies, its sensitivity for intracardiac anomalies was slightly lower.

Despite this, CT angiography is deemed suitable as an alternative to catheter angiography in complex congenital heart diseases (CHD) and proves to be valuable for preoperative planning and postoperative follow-up evaluations.[46]

Even in Enaba et al they reported that the numbers of the anomalies in the study diagnosed by CT angiography were as follows, tetralogy of Fallot (15 patients, 25%), tricuspid atresia (12 patients, 20%), Ebstein’s anomaly (4 patients, 6.5%), pulmonary atresia or stenosis (7 patients, 11.5%), truncus arteriosus (6 patients, 10%), TGA (10 patients, 17%), and TAPVR (6 patients, 10%). The research revealed that the sensitivity and specificity of CT angiography were 91.2% and 98.2%, respectively, for Tetralogy Fallot; 99.4% and 64.8%, respectively, for tricuspid atresia; 96.9% and 90.8%, respectively, for diagnosing Ebstein's anomaly; 98.2% and 95.5%, respectively, for pulmonary atresia or stenosis; 98.6% and 47.1%, respectively, for tricuspid atresia; 98.9% and 95.5%, respectively, for diagnosing transposition of great arteries; and 97.7% and 95.5%, respectively, for diagnosing TAPVR. All of these results were significantly higher than those obtained from 2D echocardiography. Therefore, they proposed that CT angiography is a more dependable imaging modality than 2D echocardiograpy.[47]

Parikh P et al had compared measures of the major pulmonary vasculature, right & left pulmonary arteries, and valve acquired from CT angiography and transthoracic echocardiography. 49 patients under the age of 17 who were suspected of having CHD were included in the study. According to Bland-Altman analysis, the mean differences (with 95% confidence limits) in diameter measurements between echocardiography and CT angiography were as follows: -0.5 mm (-3.1 to 2.2 mm) for the right pulmonary artery, -0.6 mm (-3.3 to 2.1 mm) for the left pulmonary artery, 0.7 mm (-2.5 to 3.9 mm) for the pulmonary valve, and 1.2 mm (-6.9 to 4.5 mm) for the main pulmonary artery. Based on these findings, the researchers concluded that there was adequate agreement between CT angiography and echocardiography measurements of the main pulmonary artery, branch pulmonary arteries, and pulmonary valve diameters. [48]

Nie P et al investigated the value of prospective ECG-gated high-pitch 128-slice dual-source CT (DSCT) angiography with transthoracic echocardiography in the diagnosis of congenital extracardiac vascular anomalies in infants and children. They observed that In 75 patients confirmed by surgical or catheterization findings, 17 congenital heart diseases and 162 separate extracardiac vascular anomalies were identified. High-pitch dual-source CT (DSCT) angiography showed a diagnostic accuracy of 99.67%, whereas transthoracic echocardiography (2D echocardiography) had a diagnostic accuracy of 97.89%. The sensitivity of high-pitch DSCT angiography was 97.53%, significantly higher than 2D-ECHO sensitivity of 79.62% ($\chi2 = 23.561$ and 28.013, $P<0.05$).

Interobserver agreement for image quality scoring on DSCT was excellent ($\kappa = 0.81$), with a mean image quality score of 4.1±0.7. The mean effective dose (ED) of DSCT was 0.29±0.08 mSv, demonstrating its low radiation exposure compared to other imaging modalities.

These results indicate that high-pitch DSCT angiography offers superior diagnostic accuracy and sensitivity compared to 2D echocardiography in evaluating congenital heart diseases and extracardiac vascular anomalies. The method also ensures excellent image quality with minimal radiation exposure, making it a valuable tool for clinical diagnosis and management. [49]

Jadav SP et al also expressed that prospectively ECG-gated volumetric scanning using an CT angiography scanner offers numerous advantages for cardiovascular imaging in neonates and infants. These include lower radiation doses, enhanced image quality through iterative reconstruction techniques, high diagnostic accuracy, and the capability to conduct studies without the need for breath holding. Their assessment specifically utilized a 320-detector CT angiography scanner.[61]

Ramesh M et al had The angiograms were performed using a 128-slice Philips CT scanner with a paediatric protocol, employing tube voltages (KV) ranging from 80 to 100 and tube currents (MAS) calculated based on the child's weight. Out of 280 paediatric CT cardiac angiograms conducted:127 cases were diagnosed with Tetralogy of Fallot,36 cases had total or partial anomalous pulmonary venous return,21 cases were diagnosed with transposition of the great arteries. Regarding major aortopulmonary collateral arteries (MAPCAs), 74 cases were confirmed with surgery and conventional angiography. CT angiography (CTA) correctly identified 72 of these MAPCAs, resulting in a sensitivity of 97.3% and specificity of 100%. These findings underscore the effectiveness of CTA in diagnosing complex congenital heart conditions and MAPCAs specifically, highlighting its high sensitivity and specificity compared to surgical and angiographic confirmation of echo in paediatric CHD diagnosis but acknowledges the potential utility of CTA in specific cases.[50]

Erkut Öztürk had conducted This study that investigates the diagnostic efficacy of echocardiography (echo) versus multidetector computed tomography angiography (CTA) in pediatric patients under eight years of age undergoing cardiac surgery for congenital heart disease (CHD). Conducted between August 1, 2019, and December 31, 2019, the study adhered to the Helsinki Declaration after obtaining institutional review board approval. Each case's data, including age, gender, weight, transthoracic echo, and 320-row multidetector CTA results, were recorded. Echo assessments utilized a GE Vivid S5 system with standard pediatric views and a segmental approach for cardiac morphology evaluation. Two experienced cardiologists analyzed echo images. Multidetector CTA was performed using a 320-row scanner with a non-ECG gated protocol, adjusting parameters based on patient weight and utilizing contrast injection and bolus-tracking technique. Images were reviewed by two experienced radiologists, and decisions were made by consensus. The study found echo to have significantly greater diagnostic accuracy compared to CTA across various CHD subtypes. This research underscores the importance of echo in pediatric CHD diagnosis but acknowledges the potential utility of CTA in specific cases. [60]

MATERIALS AND METHODS

A hospital based one-year cross sectional study was conducted by including the patients of different age groups diagnosed with congenital cyanotic heart disease referred from different out-patient & inpatient departments in KLES Dr. Prabhakar kore hospital and medical research Centre, Belagavi during the 01-year period from January 2023 to December 2023.

A. SAMPLE SIZE:

Formula used for sample size calculation is,

$$\boldsymbol{n = \frac{p(100 - p)Z^2}{E^2}}$$

where n is the sample size required, p is the percentage occurrence of a state or condition (proportion or prevalence), E is the percentage maximum error required, Z is the value corresponding to level of confidence required. 12.5% coarctation aortic were detected by CT. Considering similar result at 95% confidence level and 10% of maximum error, the sample size is given by,

$$\boldsymbol{n = \frac{12.5 \text{x} (100 - 12.5) \text{ x } 1.96^2}{10^2}}$$

$$\boldsymbol{n = 42.0175 \approx 42}$$

B. INCLUSION CRITERIA

Patients with probability of congenital cyanotic heart disease diagnosed by 2D Echocardiography & referred for CT angiography scan study, who will qualify underlying criteria:

a. Patient who will give written & informed consent.

b. Age group between Day 0 to 17 years

c. Cyanotic congenital heart disease patients.

d. Clinical case of cyanosis with concomitant congenital heart disease suspected.

C. EXCLUSION CRITERIA

a. Patients who had history of allergy to Intravenous iodinated contrast agent.

b. Patients with deranged renal function tests.

c. Patients with life threatening cardiac arrhythmias.

D. DATA COLLECTION PROTOCOL

Ethical clearance was obtained. Written & informed consent was obtained from all the patients and parents for pediatrics age group after explaining about the need for these radiological evaluations, their outcomes and about the data collection in their understandable language using simple terms.

Patients coming to KLEs Dr. Prabhakar Kore hospital, Belagavi during January 2023 to December 2023. Patients of age day 0 to 17 years, probably diagnosed as case of congenital cyanotic heart disease were evaluated and enrolled for the study. Examination had been conducted by using **Revolution EVO Wipro GE 128 slice Computed tomography**. All the findings were correlated with 2D ECHO in both pre operative & post operative subjects by seeing the case sheets.

Figure 8 : Revolution EVO Wipro GE 128 slice Computed tomography.

- **The specific parameters to be used include:**
  - **Scan Range**: From the thoracic inlet to the pelvic to cover all cardiac and major vascular structures.
  - **Slice Thickness**: 0.5 mm for high resolution.
  - **Contrast**: Injection of non-ionic iodinated contrast, adjusted for the patient's weight and kidney function. A 1.5 -2.0 ml/kg bolus of iodinated contrast medium was administered using a dual-head power injector preferably by cannula in the lower limb than the upper limb.
  - **Patient Positioning**: Patients were scanned in the supine position, which is standard for CCTA to ensure consistent imaging quality.
  - **Anesthesia and Sedation**: General anesthesia and sedation were routinely required for the procedure in this cohort specially in newborns.
  - **Imaging Protocol**: The entire volume of the heart and great vessels was covered in approximately 5 seconds during one breath-hold. This quick acquisition helps minimize motion artifacts.
  - **Reconstruction Techniques**: Multiplanar reconstruction (MPR), maximum intensity projection (MIP), and three-dimensional (3D) reconstructions to enhance the visualization of anatomical structures.

E. Data Recording: All imaging findings will be recorded systematically, detailing normal and pathological findings relevant to CCHD. Additional data on patient demographics, clinical presentation, and pre-scan diagnostic assumptions will also be collected.

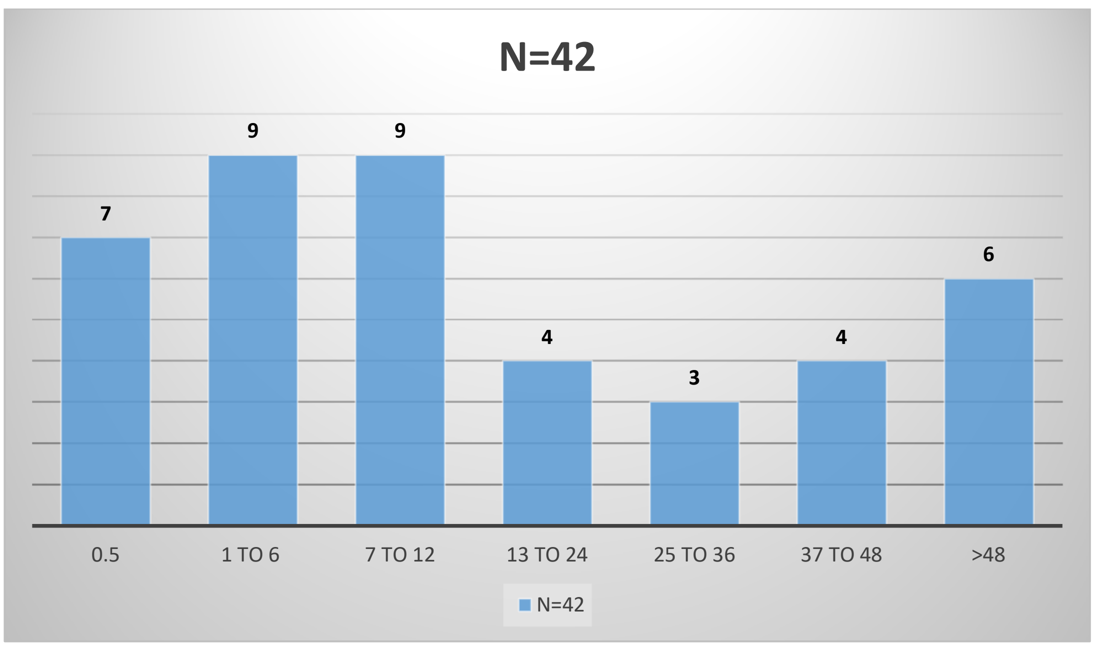
3.1 STATISTICAL ANALYSIS

As the obtained data were fitting into descriptive analysis, the values were assessed as percentages, mean and standard deviations. The difference in number of the patients with various anomalies were unable to fit the criteria for calculating diagnostic values of sensitivity, specificity, PPV and NPV as all the included study population had neither undergone surgery nor the cardiac MRI to consider any modality as gold standard. Hence, we had considered the statistical software Medcalc for obtaining the P values based on percentage differences in 2D-echocradiograpy and CT angiography. Whereas for diagnostic values were assessed by considering the findings among operated cases to obtain the true positive, true negative, false positive and false negative.

RESULTS

A. Table 4: Distribution of age

Age in months	N=42	%
0.5	7	16.7%
1 to 6	9	21.4%
7 to 12	9	21.4%
13 to 24	4	9.5%
25 to 36	3	7.1%
37 to 48	4	9.5%
>48	6	14.3%

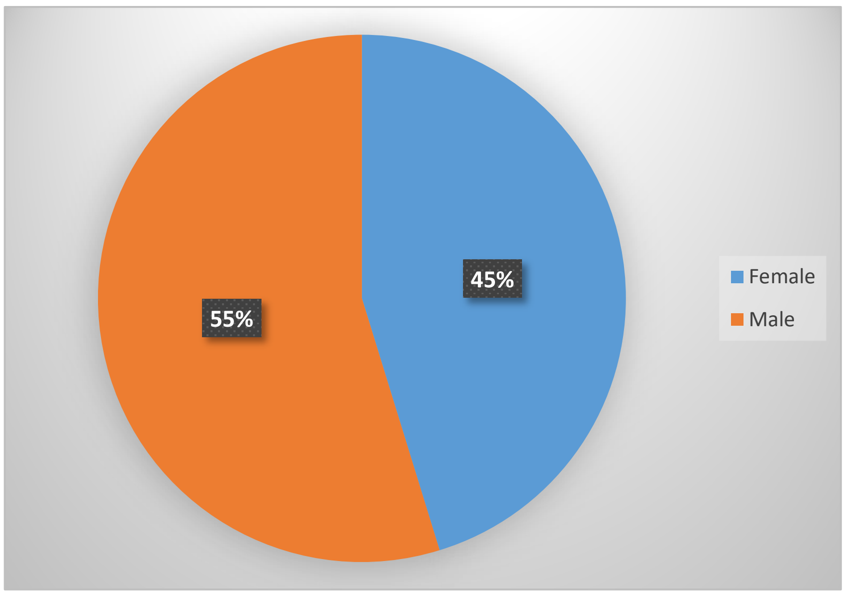


Graph 1: Age distribution

We can observe that the patients aged between 1 to 12 month were more in our study followed by 15 days old infants.

B. Table 5: Distribution of gender

Gender	N	%
Female	19	45.2%
Male	23	54.8%

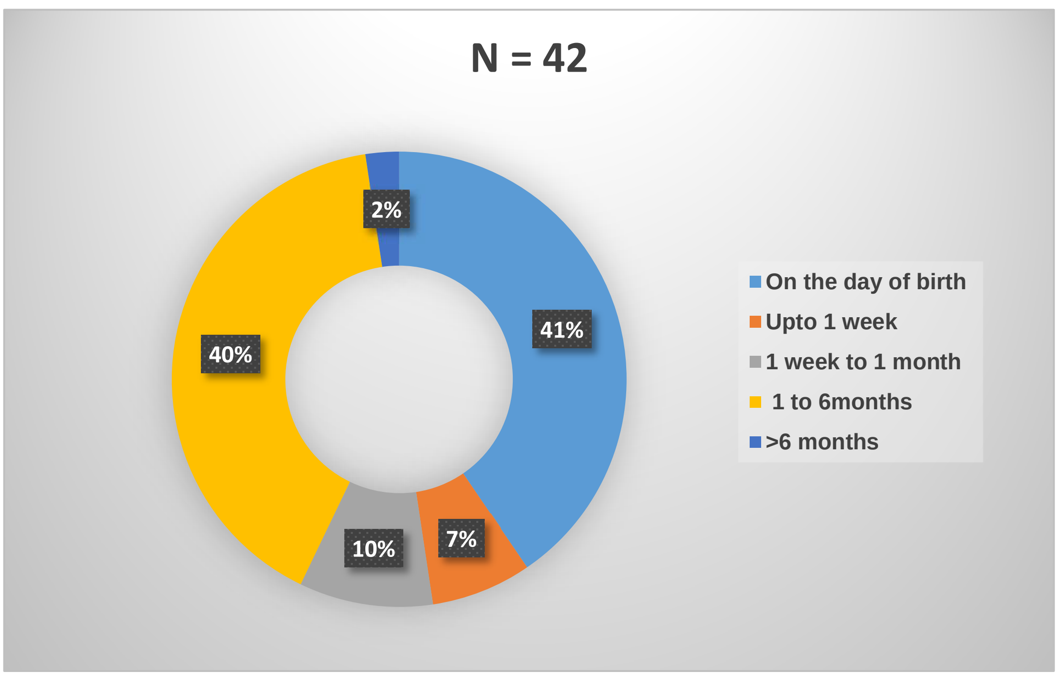


Graph 2: Gender distribution

We can see there a greater number of male subjects accounting for 23 (54.8%) and 19 (45.2%) females in this study. There was no statistically significant difference.

C. Table 6: Duration of symptoms

Duration of symptoms	N = 42	%
On the day of birth	17	40.5%
Upto 1 week	3	7.1%
1 week to 1 month	4	9.5%
1 to 6months	17	40.5%
>6 months	1	2.4%



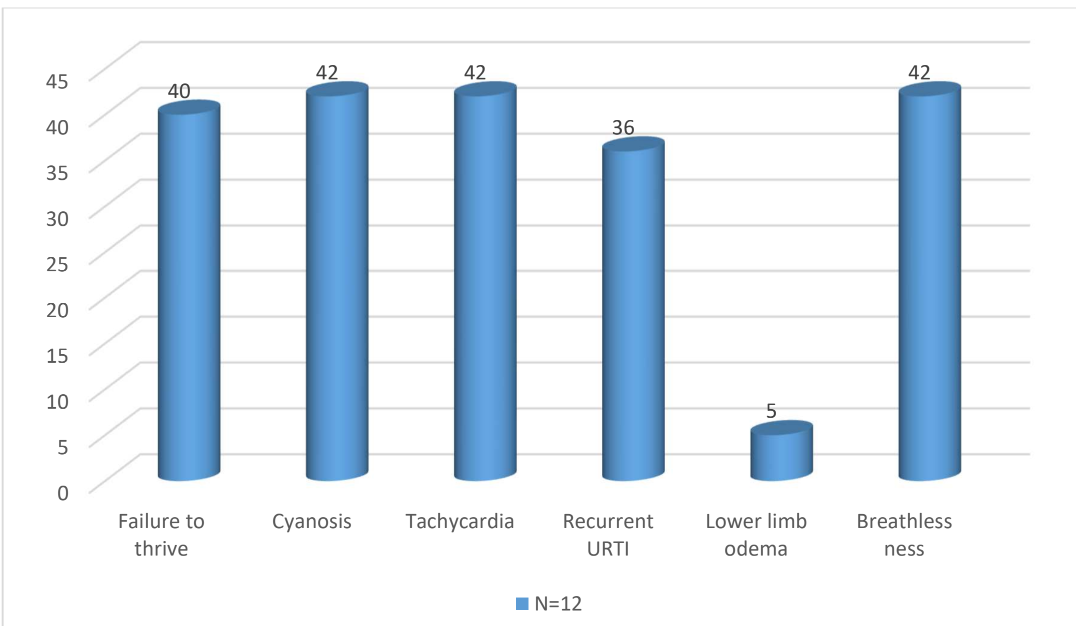
Graph 4 – Duration of symptoms

Majority of them, 17 (40.5%) had the symptoms at birth. Other 17 (40.5%) had 1 to 6 months prior visiting the OPD.

D. Table 7 : Distribution of symptoms

Symptoms	N=12	%
Failure to thrive	40	95.2%
Cyanosis	42	100.0%
Tachycardia	42	100.0%
Recurrent URTI	36	85.7%
Lower limb oedema	5	11.9%
Breathless ness	42	100.0%

All the patients had tachycardia, breathlessness and cyanosis. Rest all distributed as above.

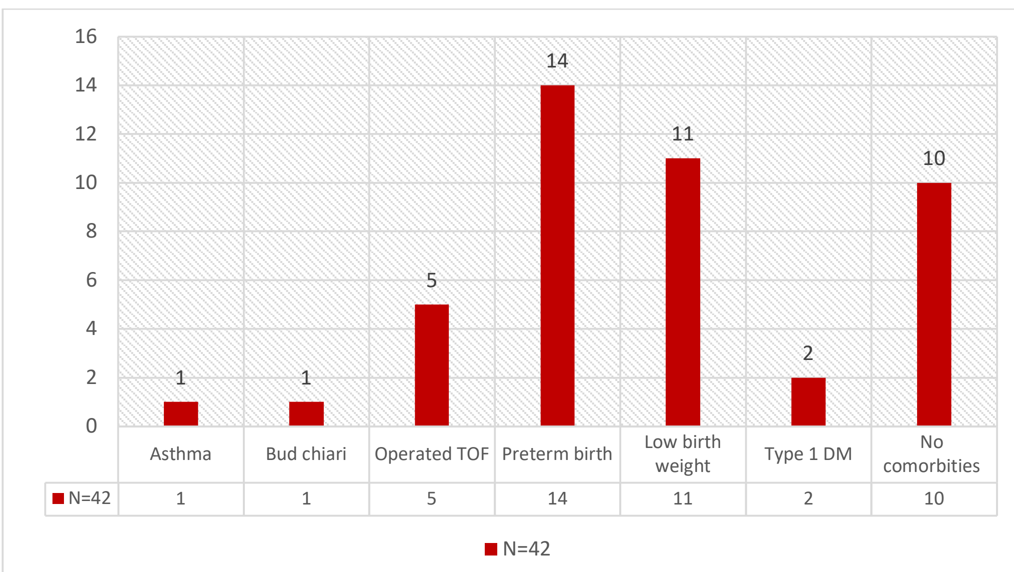


Graph 5 – Distribution of symptoms

E. Table 8 : Associated conditions

Comorbidity/past medical	**N=42**	**%**
Preterm birth	14	33.3%
Low birth weight	11	26.1%
No comorbidities	**10**	**23.8 %**
Operated TOF	5	11.9%
Type 1 DM	2	3.4%
Asthma	1	2.4%
Bud chiari syndrome	1	2.4%

Commonest associated comorbidity was Preterm birth in 14 (33.3%).

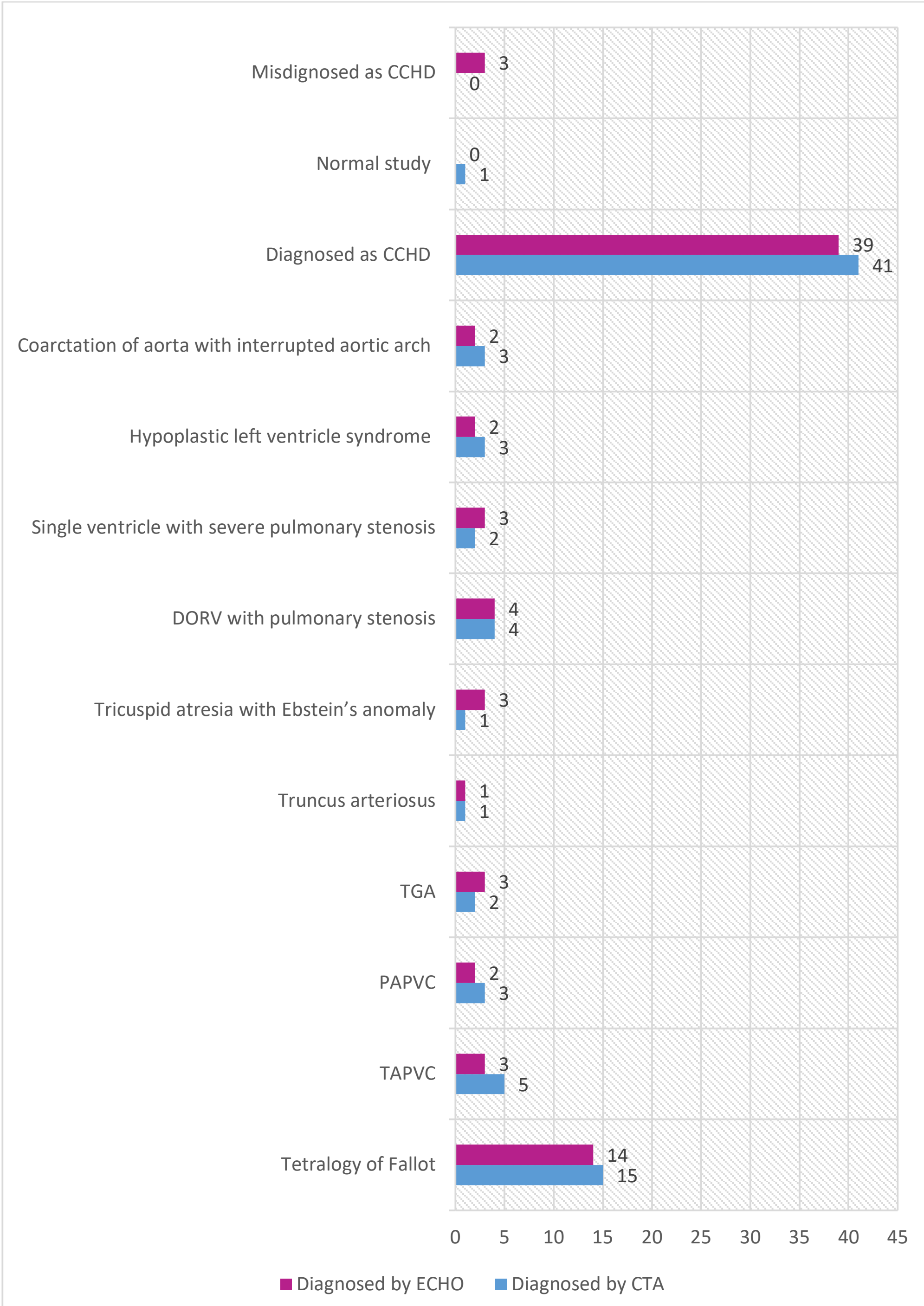


Graph 6 – Associated conditions

F. Table 9 : Final diagnoses based on both 2D echocardiography and CT angiography (CTA)

Cardiac anomaly	Diagnosed by CTA (N=42)	Diagnosed by ECHO (N=42)
Tetralogy of Fallot (TOF)	15 (35%)	14 (33%)
Total Anomalous Pulmonary Venous Connection (TAPVC)	5 (11.9%)	3 (7.1%)
Partial Anomalous Pulmonary Venous Connection (PAPVC)	3 (7.1%)	2 (4.8%)
Transposition of great vessels (TGA)	2 (4.8%)	3 (7.1%)
Truncus arteriosus	1 (2.4%)	1 (2.4%)
Tricuspid atresia with Ebstein's anomaly	1 (2.4%)	3 (7.1%)
DORV with pulmonary stenosis	4 (9.5%)	4 (9.5%)
Single ventricle with severe pulmonary stenosis	2 (4.8%)	3 (7.1%)
Hypoplastic left ventricle syndrome	3 (7.1%)	2 (4.8%)
Coarctation of aorta with interrupted aortic arch	3 (7.1%)	2 (4.8%)
Diagnosed as CCHD	41 (97.6%)	39 (92.9%)
Normal study	1 (2.4%)	0
Misdignosed as CCHD	0	3 (7.1%)

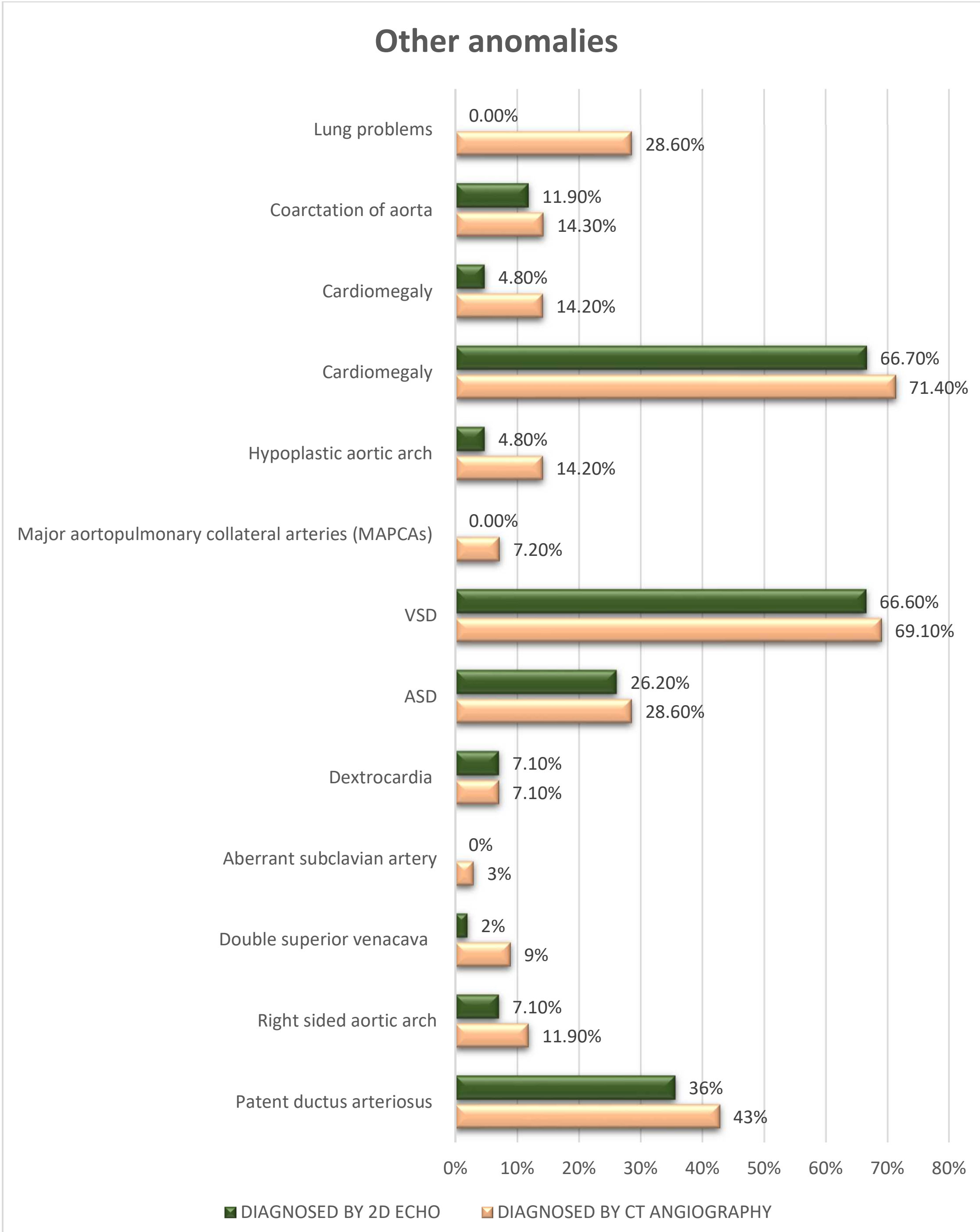
41 were diagnosed with CCHD on CT angiography whereas 39 were diagnosed with this on echocardiography. TOF was the commonest among all on both imaging modalities.



Graph 7– final diagnosis both on CT angiography & 2D echocardiography

G. Table 10 : Other anomalies diagnosed based on both 2D echocardiography and CT angiography (CTA)

OTHER ANOMALIES	ECHO (N= 42)	CTA (N= 42)
Patent ductus arteriosus	15 (35.7%)	18 (42.9%)
Right sided aortic arch	3 (7.1%)	5 (11.9%)
Double superior venacava	2 (5%)	4 (9%)
Aberrant subclavian artery	0	3 (7.1%)
Dextrocardia	3 (7.1%)	3 (7.1%)
ASD	11 (26.2%)	12 (28.6%)
VSD	28 (66.6%)	29 (69.1%)
Major aortopulmonary collateral arteries (***MAPCAs***)	0	7 (16%)
Hypoplastic aortic arch	2 (4.8%)	6 (14.2 %)
Cardiomegaly	28 (66.7%)	30 (71.4%)
Coarctation of aorta	5 (11.9%)	6 (14.3%)
Lung problems	0	12 (28.6%)



Graph 8–Other anomalies diagnosed both on CT angiography & 2D echocardiography

H. Cases missed on 2D echocardiography vs diagnosed on CTA

- Out of 05 cases of TAPVC, one of the cases diagnosed as a case of supracardiac total anomalous venous connection (TAPVC) on echocardiography but on CTA both supra & intra cardiac component of TAPVC were diagnosed.
- One of the cases diagnosed as a case of transposition of great vessels (TGA) on echocardiography, but on CTA there was no transposition of great vessels was observed.
- Out of 14 cases of tetralogy of fallot (TOF), on echocardiography anatomy of the pulmonary arteries were not clearly demonstrated. On CTA pulmonary artery anatomy was clearly delineated.
- Out of 2 cases of coarctation of aorta diagnosed on echocardiography. On CTA these 2 cases were associated also associated with hypoplastic aortic arch and type of coarctation were more clearly explained in relation with left subclavian artery which were not clearly demonstrated on echocardiography and CTA was demonstrated more sensitive for diagnosis of hypoplastic aortic arch and type of coarctation of aorta.
- The cases of tetralogy of Fallot, echocardiography could not be proved beneficial in the diagnosis of the Major aortopulmonary collateral arteries (***MAPCAs***) but in comparison CTA proved to be more accurate in the diagnosis of the MAPCAs. As in our study none of the out of 14 cases, none of the echocardiography report showed presence of collaterals arteries but on CTA out of 14 cases 07 cases showed presence of collaterals.
- Out of 05 operated cases tetralogy of fallot, the Blalock-Taussig shunt (BT shunt) patency wasn’t clearly demonstrated, but on CTA extent of stenosis & thrombosis was more accurately diagnosed.

I. Diagnostic markers

Though we did not conduct any gold standard test for confirming the CT angiography or 2D-echocardiography findings, as one of our objectives was already mentioned as sensitivity markers, to fulfil that we considered the true positive, true negative, false positive and false negative according to the outcome mentioned for those operated cases of 5 TOF and extra-polite the same and used Medcal by ourselves to obtain the below values. Prevalence is mentioned as 100% as all the cases we included were cyanotic heart diseases.

3.2 Diagnostic Results

Table 11 : Diagnostic Results of CT angiography

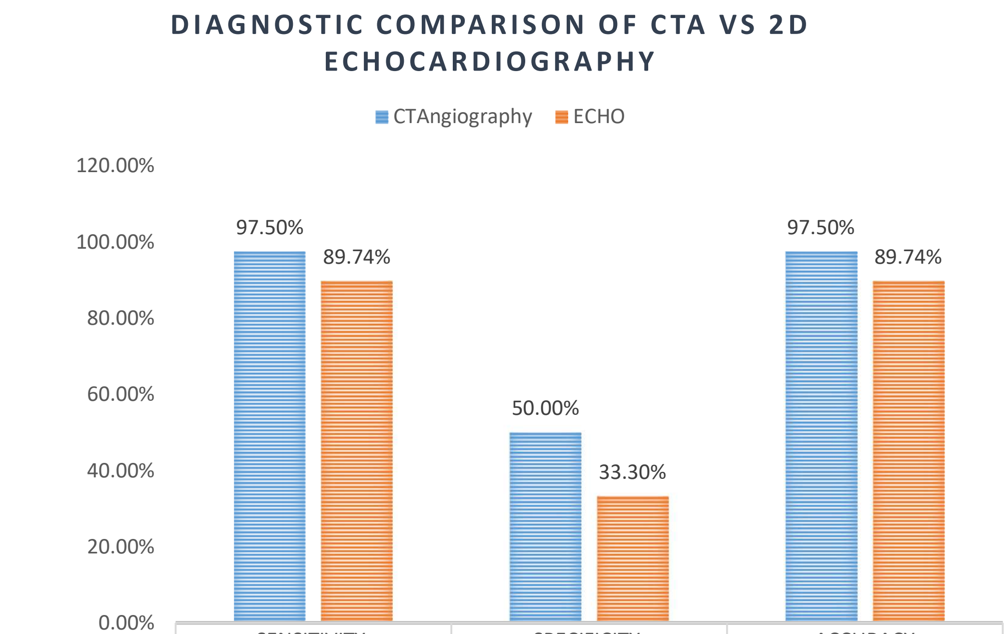
Statistic	Value	95% CI
Sensitivity	97.50%	86.84% to 99.94%
Specificity	50.00%	1.26% to 98.74%
Positive Likelihood Ratio	1.95	0.49 to 7.80
Negative Likelihood Ratio	0.05	0.00 to 0.54
Disease prevalence (*)	100.00%	
Positive Predictive Value (*)	100.00%	91.19% to 100.00%
Negative Predictive Value (*)	0	
Accuracy (*)	97.50%	87.24% to 99.93%

(*) These values are dependent on disease prevalence.

Table 12 : Diagnostic Results of CT angiography

Statistic	Value	95% CI
Sensitivity	89.74%	75.78% to 97.13%
Specificity	33.33%	0.84% to 90.57%
Positive Likelihood Ratio	1.35	0.60 to 3.02
Negative Likelihood Ratio	0.31	0.05 to 1.96
Disease prevalence (*)	100.00%	
Positive Predictive Value (*)	100.00%	90.51% to 100.00%
Negative Predictive Value (*)	0	
Accuracy (*)	89.74%	76.44% to 96.95%

(*) These values are dependent on disease prevalence.



	SENSITIVITY	SPECIFICITY	ACCURACY
CTAngiography	97.50%	50.00%	97.50%
ECHO	89.74%	33.30%	89.74%

Graph 9– Diagnostic comparison of CT angiography Vs 2D Echocardiography

DISCUSSION

Out of 42 patients we had included, 9 (21.4%) each were aged between 1 to 6 years and 7 to 12 years followed by 6 (14.3%) aged less than 18 years. 4% each were aged between 13 to 14 and 14 to 18 years. 23 (54.8%) males and 19 (45.2%) females. Three of them were aged between 25 to 36 months. In Joshi S et al, 39 children under the age of 2 years with diagnosed cyanotic CHD were evaluated. The mean age was 0.88 ± 0.95 years (range: 7 days–2 years) with male preponderance (n = 28, 68.3%).

In our study population, 17 (40.5%) had the symptoms at birth. Other 17 (40.5%) had 1 to 6 months prior visiting the OPD. 4 (9.5%), 3(7.1%) and 1(2.4%) had the symptoms for 1 week to 1 month, upto 1 week and >6months before OPD consultation respectively. All 42 patients had cyanosis, breathlessness and tachycardia, either constantly or on excretion. 40 (95.2%) had Failure to thrive. 36 (85.7%) had Recurrent URTI. Lower limb odema was observed among 5 (11.9%).

14 (33.3%) had Preterm birth, 11 (26.1%) had history of low birth weight, 5 (11.9%) were already operated cases of TOF. Two of them had type I Diabetes and were on treatment. One each were presented with asthma and Bud Chiari malformation. Even in Joshi S et al, commonest cyanotic CHD was TOF among 24/39. The spectrum of CHD included TOF, TOF with pulmonary atresia, double outlet right ventricle-TOF type, pulmonary atresia, and pulmonary stenosis. This was common finding in both CT and echo.

On CT angiography, we found 41 (97.6%) of them were diagnosed as CCHD whereas 39 (92.9%) on 2D Echo. Of all the CCHDs TOF was the commonest. Incidence on CT and ECHO were 15 (35%) and 14 (33%). Other findings on CT angiography were, 5 (11.9%) with TAPVC, DORV with pulmonary stenosis among 4 (9.5%), PAPVC, Hypoplastic left ventricle syndrome, Coarctation of aorta with interrupted aortic arch in 3 cases (7.1%), TGA and Single ventricle with severe pulmonary stenosis in 2 (4.8%), one each had Truncus arteriosus and Tricuspid atresia with Ebstein's anomaly. There was no missed diagnosis on CT angiography.

In our study, the tetralogy of fallot was most commonly observed cyanotic heart disease. The main drawback on echocardiography was is to delineate the pulmonary artery anatomy.

Pulmonary stenosis & atresia was better diagnosed on the CTA angiography as compared to echocardiography. Multiple Pulmonary Collateral Arteries (MPCAs) develop in response to congenital heart defects that obstruct or limit blood flow through the pulmonary arteries.

In our study, out of 14 cases of TOF, CTA diagnosed 06 cases with presence, location, size, and course of these collateral arteries which were clearly missed on the echocardiography. For identification of MPCAs using CTA is crucial for assessing the overall hemodynamic and functional status of the lungs in patients with cyanotic heart diseases. In our study also CT angiography played a critical role in identifying and characterizing these vessels, aiding in clinical decision-making and management strategies for patients.

Presence of hypoplastic aortic arch associated with coarctation of the aorta was better demonstrated on the CTA as most of the cases diagnosed on echocardiography was missed these findings.

In Enaba MM et al, tetralogy of Fallot (25%), tricuspid atresia (20%), Ebstein's anomaly (6.5%), pulmonary atresia or stenosis (11.5%), truncus arteriosus (10%), TGA (17%), and TAPVR (10%) on CT angiography among sixty cases. Whereas other cardiac findings on 2D echocardiography were DORV with pulmonary stenosis in 4 (9.5%). 3 (7.1%) each had TAPVC, PAPVC, TGA, Tricuspid atresia with Ebstein's anomaly (missed in 2 cases by CT angiography), Single ventricle with severe pulmonary stenosis (missed in 1 case compared to CT), two each had Hypoplastic left ventricle syndrome and Coarctation of aorta with interrupted aortic arch (missed in one each compared to CT). there was one normal study on CT angiography whereas non on echo. Similarly, missed cases on CT were zero whereas 3 were missed on 2D echocardiography. [47]

Joshi S et al described their outcome, in which they have reported that in both echocardiography and CTA, the pulmonary artery was reported as normal in course and caliber in four patients. Pulmonary artery stenosis, atresia, and hypoplasia were observed in 20, 3, and 2 patients, respectively. Six patients with pulmonary atresia reported on echocardiography were found to have stenosis on CTA.[51]

On analyzing the other findings only, 28 (66.6%) had VSD, and 28 of them with associated cardiomegaly on 2D echocardiography. Further 15 (35.7%) with PDA, ASD in 11 (26.2%), 5 (11.9%) with right aortic arch, 3 (7.1%) of them had Dextrocardia and 3 (7.1%) right sided aortic arch. Two each had Double superior Ven cava and Hypoplastic aortic arch. Whereas on CT angiography, 30 (71.4%) had cardiomegaly, 29 (69.1%) with VSD, 18 (42.9%) had PDA, 12 (28.6%) with ASD, 6 (14.3%) each with Right sided aortic arch and Hypoplastic aortic arch. 5 (11.9%) with Right sided aortic arch, 4 (9%) Double superior venacava, 7 (16%) Major aortopulmonary collateral arteries (***MAPCAs***), 3 (7.1%) each with Aberrant subclavian artery and Dextrocardia. With this we can see that additional findings were more efficiently diagnosed on CT angiography than 2D echocardiography. Also, the pulmonary changed were observed among twelve cases which we could not of 2D echocardiography. With respect to this CT angiography had radiologically significant in diagnosing both common cardiac, extra-cardiac and additional features in cardiovascular components.

With respect to this difference, the description by Stin B et, Ghnaati H et al and Rajesh Kannan R et al would help us. In their separate works have explained about the advantages of CT angiography. This has been one of the High-definition imaging producing the accurate radiological outcome in seconds. Also, vascular structures as lesser as 1 to 2 mm could also be found effectively on CT angiography. Computed tomography (CT) has emerged as a reliable non-invasive first-line imaging modality for detecting coronary abnormalities and other cardiac diseases. It excels in accurately identifying shunt size, location, and flow direction. Importantly, patients with metallic devices and pacemakers can safely undergo CT imaging. CT also enables analysis of cardiac dimensions and function, although segmental contraction definition may be less precise compared to MRI or other modalities. Assessment of prosthetic valve function is another area where CT proves efficient.[53’54]

Research by Hayabuchia Y et al demonstrated CT's capability in detecting 53 out of 54 intra-cardiac and extra-cardiac anomalies in neonates with congenital heart disease (CHD). Similarly, studies by Paul JF et al highlighted CT's value in assessing extracardiac systemic and pulmonary vascular features.[55]

For radiologists specializing in cardiovascular radiodiagnosis, possessing precise knowledge of cardiovascular anatomy, physiology, and surgical techniques is indispensable. This knowledge ensures accurate interpretation and effective utilization of CT imaging in clinical practice.

Sensitivity, specificity, PPV, NPV and accuracy for CT angiography are 97.5%, 50%, 100%, 0% and 97.5%. similarly, for 2D echocardiography it was 89.74%, 33.3%, 100%, 100% and 89.74% respectively. Though the PPV is 100% for both, the specificity and accuracy had moderately significant difference. Similarly, in Enaba MM et al stated sensitivity and specificity of multidetector computed tomography (CT angiography) for diagnosing Tetralogy of Fallot were reported as 91.2% and 98.2%, respectively. These metrics indicate that CT angiography is highly effective in correctly identifying individuals with Tetralogy of Fallot (sensitivity) and accurately ruling out those without the condition (specificity). but 2D echocardiography also had almost similar outcome. Hence, they had calculated agreement value which was 0.776 for complex features, 0.87 for major cardiac and 0.57 for complex vessel involved cases as well. To substantiate our outcome, However, echocardiography may misdiagnose certain cases of valvular or arterial stenosis as atresia or may fail to visualize the structures entirely. Such patients necessitate further evaluation with CTA as per Joshi S et al. In addition, they even further produced that CTA is recommended for the measurement of the calibers of the pulmonary arteries and the pulmonary valve in all patients with pulmonary stenosis and/or atresia. [47,51,53]

They elaborate that due to the above reasons as well as the additional information provided by CTA in the form of coronary artery variations, extracardiac vascular abnormalities like major aortopulmonary collaterals, or extracardiac structural abnormalities (such as the lung and tracheobronchial tree), the authors recommend CTA in all cases of CHDs with right ventricular outflow tract obstruction. Even Malik et al demonstrated poor agreement between echocardiography and CT in the evaluation of extracardiac findings of CHDs as in pulmonary atresia and transposition of great arteries which was way lesser than our outcome and hence, they concluded as CT to be considered as first-line modality in the detecting CCHDs.

CONCLUSION

Commonest age group presented to us was 1 to 12 years. Male children were more than females. TOF was the most common anomaly observed. Cardiomegaly was commonest associated feature on both 2D echocardiography and CT angiography. There was no missed diagnosis on CT angiography but three missed on 2D echocardiography. Sensitivity, specificity, PPV, NPV and accuracy for CT angiography are 97.5%, 50%, 100%, 0% and 97.5%. similarly, for 2D echocardiography it was 89.74%, 33.3%, 100%, 100% and 89.74% respectively. The diagnostic markers were higher for CT angiography compared to 2D echocardiography. There were 12 pulmonary pathologies found on CT and none on 2D echocardiography.

- Firstly, CT angiography has demonstrated high sensitivity and specificity in identifying CCHD, surpassing traditional methods such as echocardiography. This superior diagnostic capability stems from CT angiography ability to provide detailed and comprehensive visualizations of both cardiac and extracardiac anatomies, which is crucial for accurate diagnosis and effective surgical planning.
- Echocardiography, for instance, although non-invasive and widely accessible, often struggles with image clarity in patients with complex anatomical structures or those who have undergone previous cardiac surgeries. Cardiac catheterization, despite its precision, carries risks associated with its invasive nature, including potential vascular complications and the general discomfort associated with invasive procedures. In contrast, CT angiography offers a non-invasive alternative that provides comprehensive and detailed visualizations of the cardiac and extracardiac anatomies without these associated risks.

- The superior diagnostic capability of CT angiography stems from its ability to capture high-resolution, cross-sectional images of the heart and surrounding structures within seconds. This capability allows for an unparalleled view of the cardiovascular system, revealing subtle anomalies that might be missed by other imaging modalities. By providing a detailed roadmap of a patient's cardiac anatomy, surgeons can plan procedures with greater precision, anticipate potential challenges, and strategize more effective interventions.
- The study's findings suggest that CT angiography can significantly improve the diagnostic workflow for CCHD by providing a faster, non-invasive, and highly accurate diagnostic tool. This can lead to earlier and more precise treatment interventions, potentially improving clinical outcomes and reducing the need for more invasive diagnostic procedures, which carry greater risks and discomfort for podiatric patients.
- Based on these findings, several recommendations for the use of CT angiography in clinical practice can be made:
    - Incorporation into Standard Diagnostic Protocols
    - Utilization in Pre-surgical Planning
    - Training and Protocols for Optimal Use
    - Ongoing Research and Development

In conclusion, the incorporation of CT angiography into the diagnostic and management pathways for CCHD represents a significant advancement in pediatric cardiology, offering a blend of speed, precision, and safety that is paramount for treating vulnerable pediatric populations. These benefits underscore the importance of broader adoption and optimized use of CT angiography in clinical settings worldwide

SUMMARY

- The study was a cross-sectional study.
- Patients presenting to the department of radiology with history of cyanosis and suspected or confirmed case of cyanotic congenital heart disease.
- 42 cases were included in the study after observing the inclusion and exclusion criteria.
- All patients first underwent Multidetector computerized pulmonary angiography.
- Findings of cardiac and vascular anomalies were evaluated and diagnosis was made based on clinical history and findings were correlated with the 2D-Echocardiograpy.
- A 128-slice CT scanner is highly valuable in the management of congenital heart diseases (CHD) due to its advanced imaging capabilities. It offers high spatial resolution, fast scanning speeds, and 3D imaging capabilities, which are crucial for detailed assessment of complex cardiac structures and anomalies. The scanner allows for accurate evaluation of the heart chambers, valves, and coronary arteries, aiding in diagnosis, surgical planning, and monitoring of CHD patients. Importantly, it provides these benefits in a non-invasive manner with reduced radiation dose, making it particularly suitable for pediatric patients and adults with CHD. Overall, the 128-slice CT scanner enhances the precision and safety of diagnostic imaging in congenital heart diseases, contributing significantly to improved patient care and outcomes.
- Echocardiography (Echo) is noninvasive and Initial choice for evaluating cardiac function, structure, and dynamics of blood flow with few Limitations in visualizing detailed anatomical structures and coronary arteries.

- In comparison CT Angiography (CTA) offers High-resolution Imaging and good for surgical Planning.
- Initial Evaluation: Echocardiograpy is typically the first-line modality due to its non-invasiveness and ability to assess cardiac function and Complex Cases , CT Angiography is reserved for cases requiring detailed anatomical evaluation where echo alone is insufficient.
- Together, echo and CT Angiography provide a comprehensive evaluation of CHD:
  - Echo offers functional assessment and dynamic monitoring.
  - CTA provides detailed anatomical information necessary for precise diagnosis and treatment planning.
- In managing congenital heart disease, the choice between echocardiography and CTA depends on the clinical question, patient characteristics, and imaging goals, ensuring a balanced approach that optimizes diagnostic accuracy while minimizing risks associated with radiation and contrast exposure.

LIMITATIONS

Despite its strengths, this study is not without limitations, which could open avenues for further research:

a) Neither the operative findings were noted nor any other gold standard tests had been conducted to compare the actual outcomes of 2D echocardiography and CT angiography to find their diagnostic accuracy. For calculation of the same, we had assumed that operative findings of the study samples being similar to the findings before. Hence, these values might differ if the actual gold standard test such as CCE would be compared.

b) Sample Size and Diversity

One significant limitation in the current study is the sample size and demographic diversity, which may restrict the generalizability of the findings. The diversity in genetic backgrounds, environmental factors, and healthcare access can profoundly affect disease presentation and outcomes, as well as the efficacy of diagnostic tools like CT angiography. Future studies aiming to validate and expand upon the current findings should consider including a broader geographic and demographic sample. This expansion would not only enhance the reliability of the data but also provide deeper insights into how demographic factors might influence the performance and utility of CT angiography in diverse patient populations. Increasing the sample size would also improve the statistical power of the study, thereby providing more robust data for evaluating the effectiveness of CT angiography in diagnosing CCHD.

c) Long-term Outcomes

Another critical aspect that requires further exploration is the impact of CT angiography-based diagnosis on long-term clinical outcomes. While the current study primarily focuses on immediate diagnostic outcomes, the ultimate value of any diagnostic tool lies in its ability to improve long-term health outcomes, including survival rates and quality of life. Longitudinal studies are needed to track these outcomes over time, providing essential data on the efficacy of CT angiography in improving the clinical trajectory of patients with CCHD. Such studies would help clarify whether early and accurate diagnosis with CT angiography leads to be 2D echocardiography-targeted treatments, reduced complication rates, and ultimately, enhanced long-term survival and quality of life for these patients. [61]

d) Technological Advancements

As with any medical technology, the continuous evolution of CT angiography poses both opportunities and challenges. Ongoing advancements in CT angiography technology promise improved imaging capabilities, faster processing times, and reduced risks, particularly in terms of radiation exposure—a significant concern in pediatric imaging. Continued research is necessary to evaluate these technological advancements, ensuring that they not only enhance diagnostic precision but also prioritize patient safety (Bu et al., 2016). It is crucial that future studies continuously monitor the safety profile of newer CT angiography models, especially concerning radiation doses, to mitigate any potential risks associated with cumulative radiation exposure in children. [62]

e) Comparative Effectiveness Research

Finally, there is a need for comparative effectiveness research that evaluates CT angiography in relation to other emerging imaging technologies, such as cardiac Magnetic Resonance Imaging (MRI). While CT angiography offers specific advantages in speed and detail, MRI offers excellent soft tissue contrast and does not involve radiation exposure, making it an appealing choice for repeated imaging in pediatric patients. Comparative studies could provide critical data on the relative effectiveness, safety, and cost-efficiency of these technologies, helping to establish a more evidence-based approach to selecting appropriate imaging modalities for specific clinical scenarios. [63]

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ANNEXURES – I

INFORMED CONSENT FORM

"Role of 128 slice multi-detector computed tomography in evaluation of congenital cyanotic heart diseases: hospital based one year cross sectional study at KLES Dr. Prabhakar kore hospital and medical research center"

PRINCIPAL INVESTIGATOR: BS0121001

Objective: To study role of 128 slice multi-detector computed tomography in evaluation of cyanotic congenital heart diseases and to correlate the findings with 2D echocardiography in both pre-operative and post-operative patients.

Introduction: Your child is being invited to participate in this study to see the role of the 128 slice MDCT angiography in diagnosis of congenital cyanotic heart disease.

Explanation of procedure: If, you agree to be part of the research study on behalf of your child and as a guardian, you will be asked the relevant history and your child/ward will be subjected to relevant clinical examination and investigations.

BENEFITS:

1. Accurate diagnosis.
2. Non-invasive.
3. Short duration of study.
4. Cost effective.

ALTERNATIVES: If patient is not willing to take part in the study, his / her treatment or any other further investigations the patient wants to undergo, in future, in KLE will not be affected by his / her decision

VOLUNTARY PARTICIPATION/WITHDRAWAL: Taking part in this study is voluntary on behalf of my child as a guardian. I may choose not to take part in this study, or if I decide to take part, I can later change my mind and withdraw from the study. My decision will not change the present or future health care or other services that I receive. The study doctor or the sponsor may stop my participation in this study. I will tell if any important new findings that may change my willingness to continue to take part. If I choose not to take part in the study I will receive the standard treatment for patients with my condition.

COSTS: NIL (The study is to be conducted on the participants who are advised CT angiography by the referring consultant and the participants will bear the charges for it.)

PAYMENT FOR PARTICIPATION: No incentive will be paid to you for participating in this study.

COMPENSATION: In the event that I become injured as a result of taking part in this study, treatment whatever available at KLE hospital, Belagavi, will be offered to me. No reimbursement, compensation or free medical care is given.

CONFIDENTIALITY: All information collected from me about my child during the course of the study will be kept confidential to the extent permitted by the law. The code numbers will identify me in this research record. Information from this study may be published but my identity will be confidential in any publication.

If any enquiries in the future or in case of research related injury illness, you may contact following person.

REGISTRATION NO: BSO121009	**DR. _____________**	**DR. HARSHA HEGDE,**
Post-Graduate, Department of Radio-Diagnosis. J.N. Medical College, Belagavi	Guide, Professor, Department of Radio-Diagnosis J.N. Medical College, Belagavi	CHAIRPERSON, JNMC, IEC & SCIENTIST D, ICMR, NATIONAL INSTITUTE OF TRADITIONAL MEDICINE, BELAGAVI

CONSENT TO PARTICIPATE IN RESEARCH STUDY:

1. I understand that I am participating in the study on behalf on my child as a guardian.
2. I confirm that I have read and understood the information in the patient information sheet. Procedure is explained to me in detail along with information about the advantages and disadvantages of taking part in the study. I have been given the opportunity to discuss all aspects of the trial,to ask questions and hereby consent to participation in the trial outlined above.
3. I understand that the decision to take part in this study is completely voluntary and I am aware that I can choose to withdraw from the study atany point of time.
4. I consent to the photographing or recording of the procedure to be performed including portions of my body, for medical, scientific or educational purposes provided my identity is not revealed in the pictures or by the descriptive texts accompanying them.
5. I understand that there is no significant risk involved in the test that would be done in this study.
6. No guarantee or assurance has given by anyone as to the results that maybe obtained.
7. My signature on this form signifies that I have willingly decided to participate after understanding the above information.

Participant's / legally authorized representatives name ___________

Signature _____________________

Name and signature of witness _____________________

Investigators name and Signature: ……………………………….

Date:

Place: Belagavi

ANNEXURE II -PROFORMA

PROFORMA

ROLE OF 128 SLICE MULTI-DETECTOR COMPUTED TOMOGRAPHY IN EVAULATION OF CONGENITAL CYANOTIC HEART DISEASE: ONE YEAR HOSPITAL BASED CROSS SECTIONAL STUDY

Patient identification number:

Age & sex:

Referred by: Self/ Physician

Presenting complaints:

Symptoms	Present	Absent	If present then Duration of illness
Breathlessness			
Failure to thrive			
Cyanosis			
Lower limb swelling			
Tachypnea			
Cyanotic spells			
Weak pulse			
Tachycardia			

Past medical history:

H/o TB ☐ H/o Allergies ☐ (please specify):-

Past surgical history:

Birth history:

Hospital admission history:

Family history:

Echo findings:

Ct pulmonary angiography findings with ECHO correlation:

Ct findings	ECHO correlation

Provisional diagnosis on 2D echocardiography:

Final diagnosis on CT angiography:

Extra findings diagnosed on CTA	

ANNEXURE III – PHOTOGRAPHS

CASE - 1

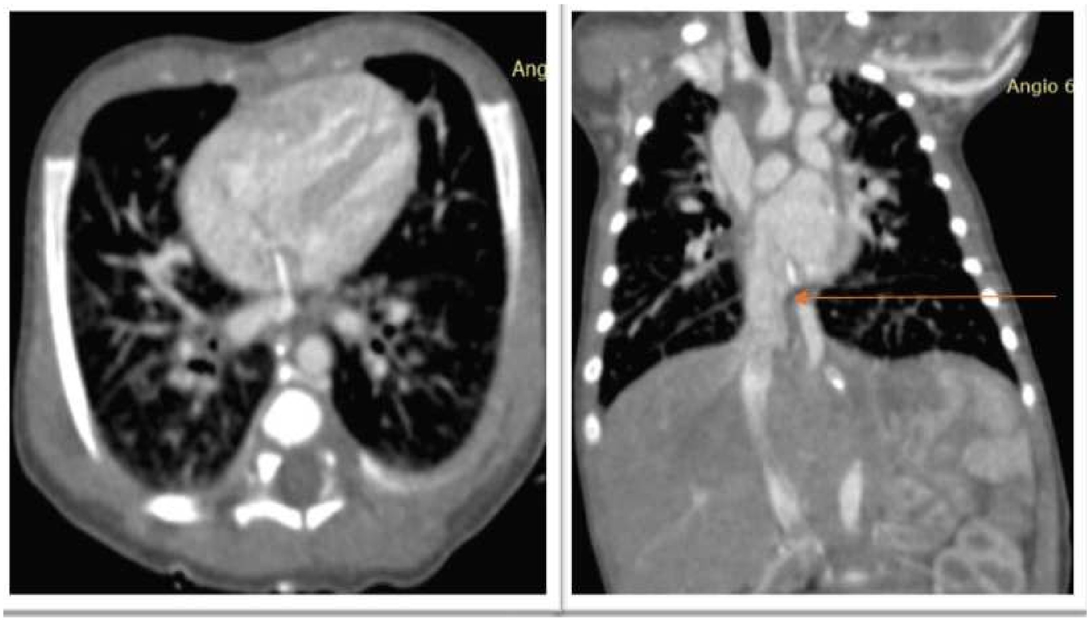


Figure 1 & 2 : Axial & coronal section of CTA shows bilateral inferior pulmonary veins seen to drain into single vertical vein transverse inferiorly through diagram into the inferior venacava (infra-cardiac TAPVC)

CASE- 2

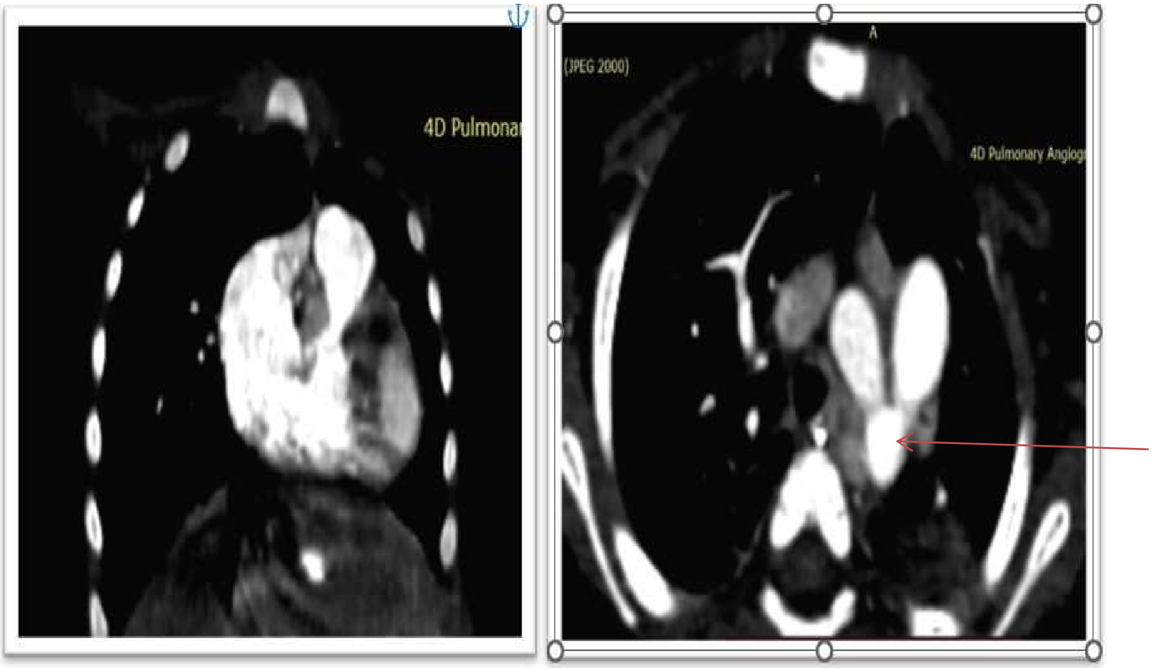
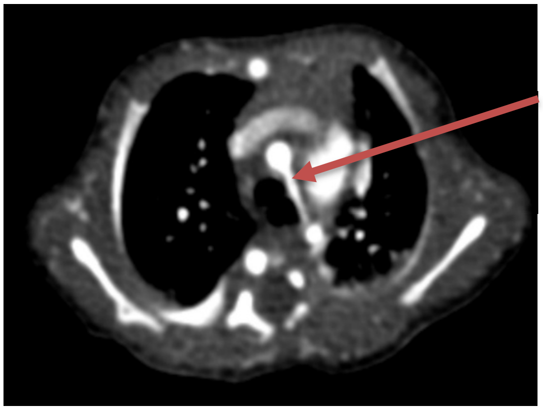
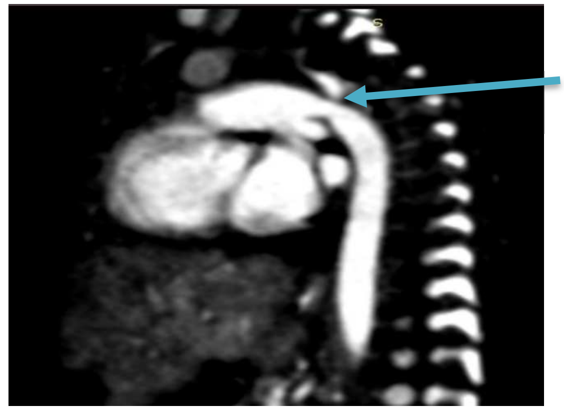
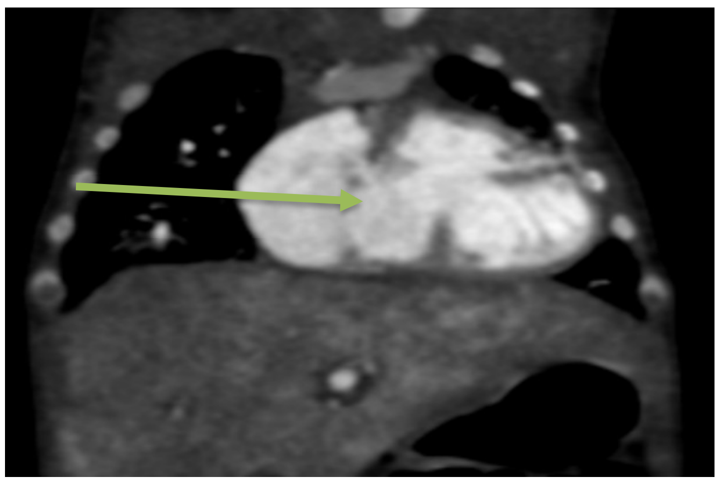


Figure 3 & 4 : Coronal & axial section of CTA showing stenosis at the origin of pulmonary artery with right ventricle hypertrophy with ventricle septal defect- Tetralogy of fallot with large patent ductus arteriosus between descending aorta & pulmonary artery

CASE -3

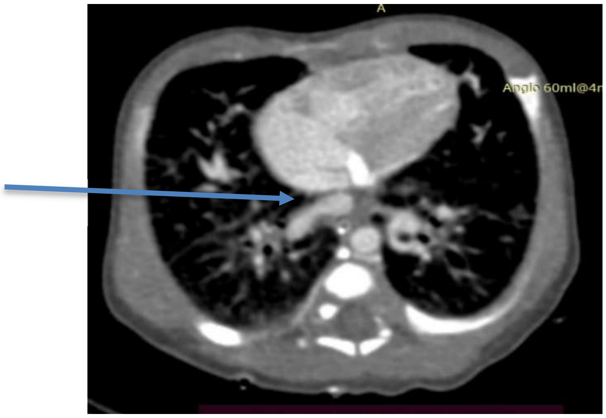


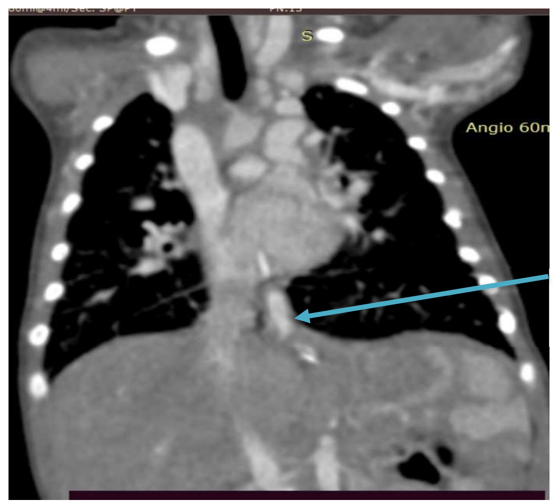




- Figure 5 & 6 - suggestive of hypoplastic and interrupted aortic arch (distal to origin of left subclavian - type A1) with large patent ductus arteriosus
- Figure 7 - Large ventricular septal defect

CASE- 4





- Figure 8, 9,10,11 - features are suggestive of complex (combined supra and infra cardiac) Total anomalous pulmonary venous circulation (TAPVC) - Type IV

CASE- 5 & 6

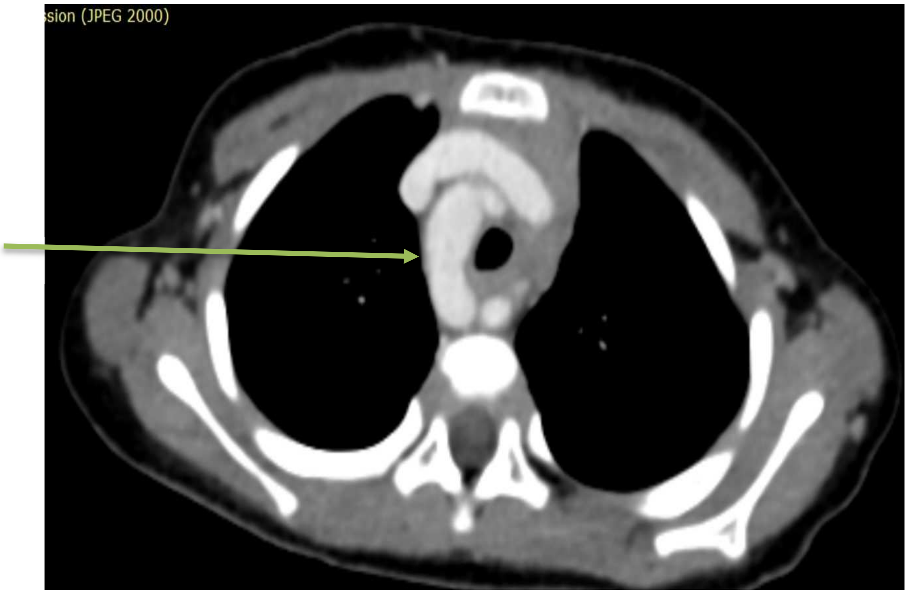


Figure 12- Right sided aortic arch

Figure 13- Single ventricle

CASE- 7

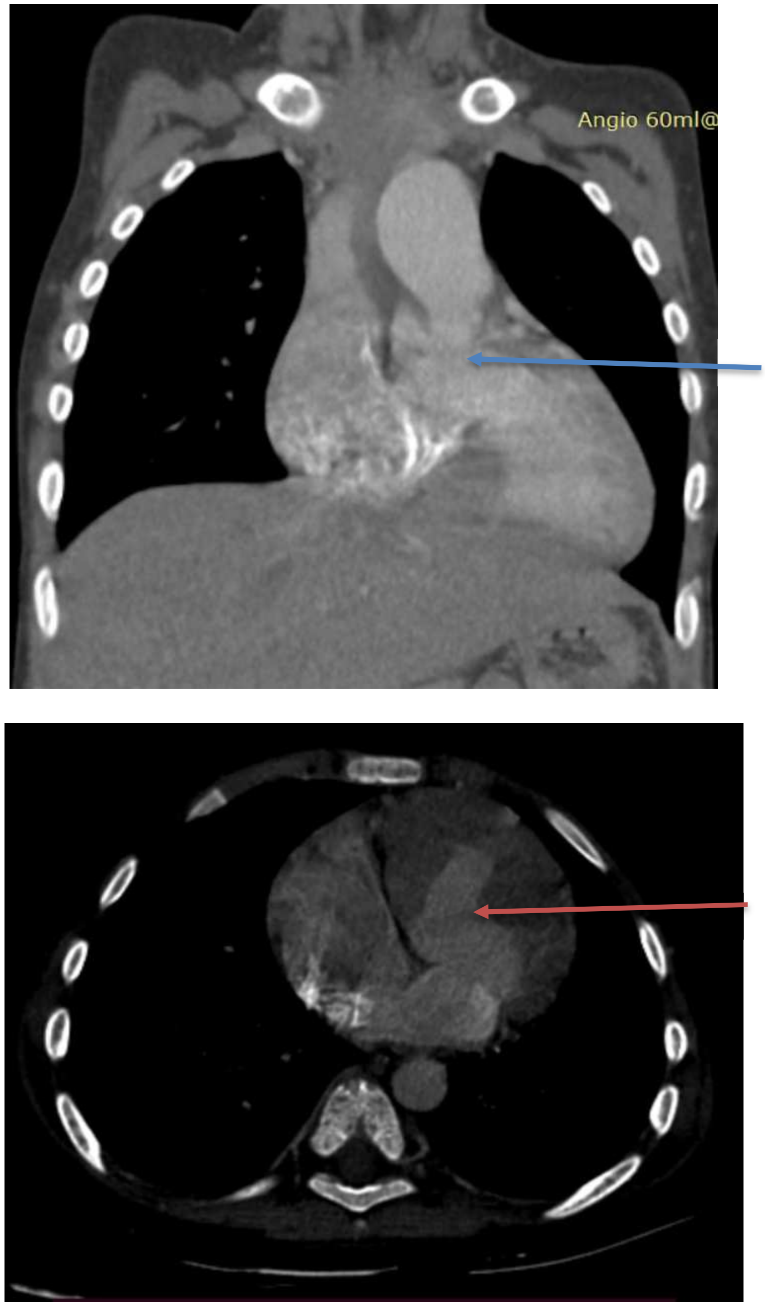
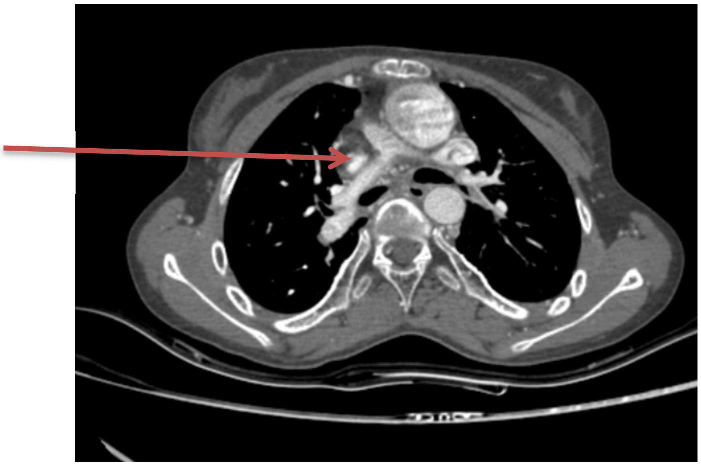
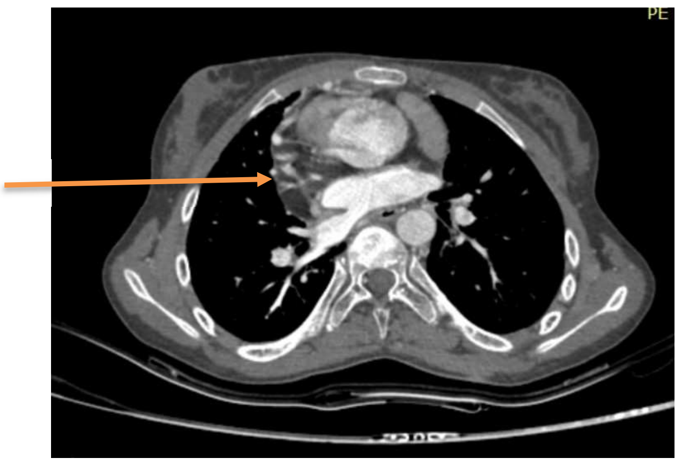
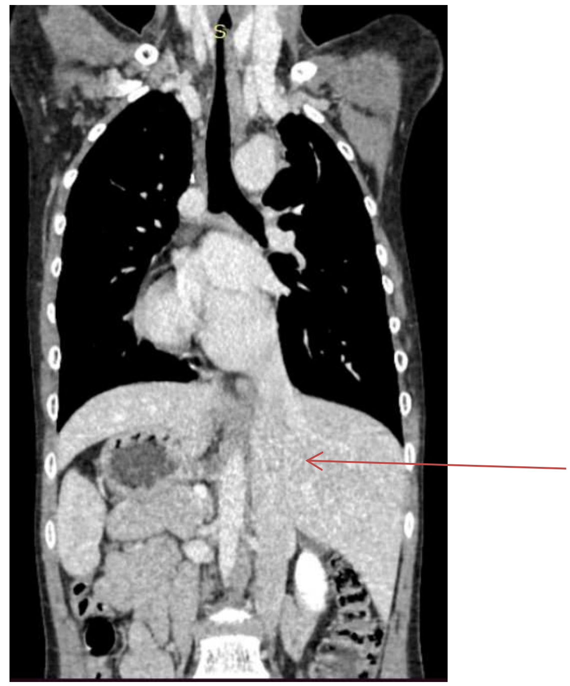


Figure 14 & 15 - Double outlet right ventricle

CASE- 8







Operated case of tetralogy of fallot

- Figure 16, 17- chronic thrombosed BT shunt with Major aorto-pulmonary collaterals
- Figure 18- Situs inversus totalis

CASE 9 & 10

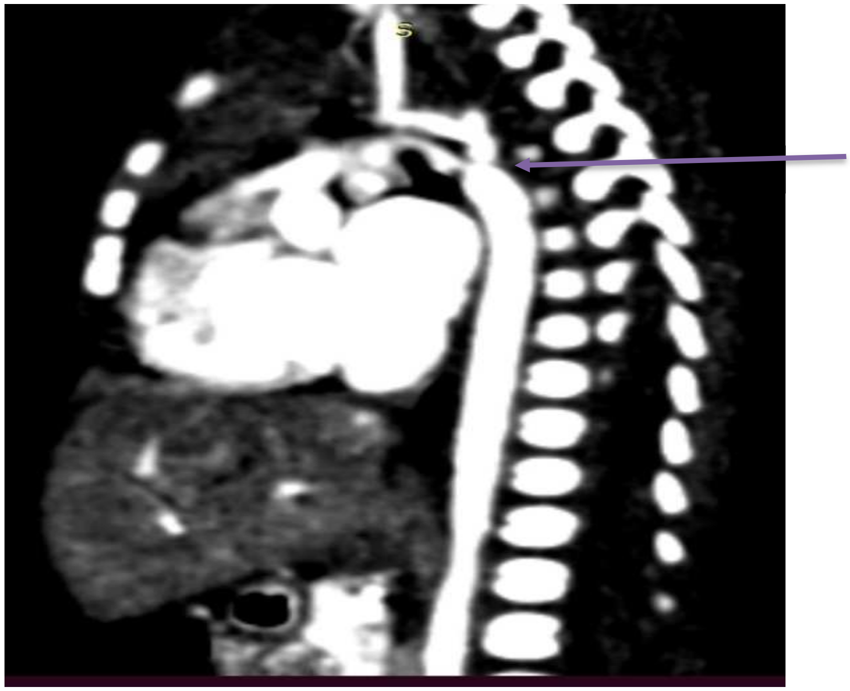


Figure 19 – Coarctation of aorta with hypoplastic aortic arch

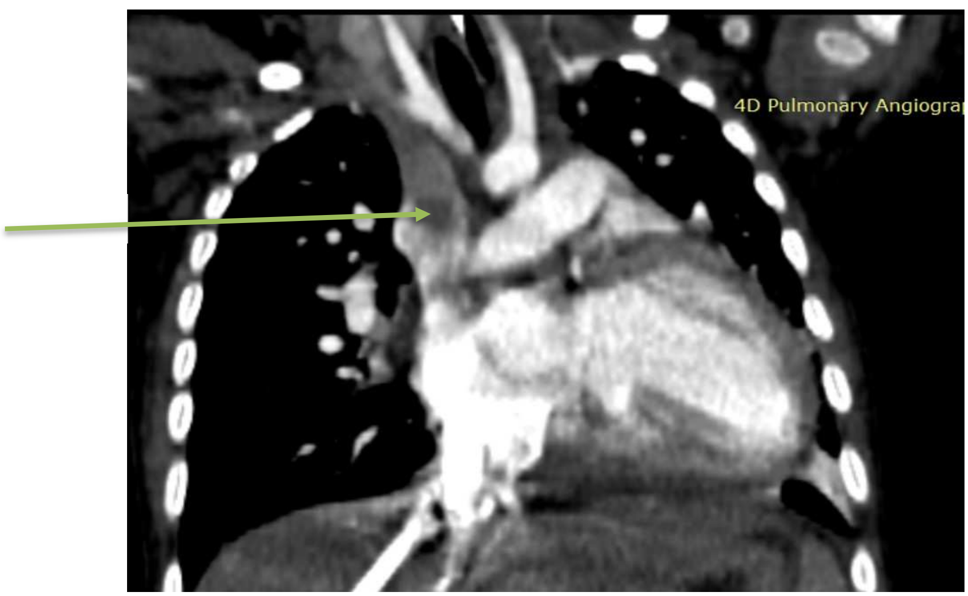


Figure 20 – Operated case of tetralogy of fallot with partially thrombosed Blalock–Taussig Shunts

Key to Master chart

CODING FOR CONGENITAL CYANOTIC HEART DISEASES AND ASSOCIATED ANOMALIES

S.NO	ANOMALIES	CODING
1.	NO ANOMALY	**0**
2.	TETRALOGY OF FALLOT (TOF) • VENTRICULAR SEPTAL DEFECT (VSD) • OVERIDING OF AORTA • PULMONARY STENOSIS • RIGHT VENTRICULAR HYPERTROPHY (RVH) • PATENT BLALOCK THOMAS TAUSSING SHUNT (BT SHUNT) • STENOSED BT SHUNT	**1,2,3,4, 5, 6** **1** **2** **3** **4** **5** **6**
3.	TRUNCUS ATERIOSUS	**7**
4.	TRICUSPID ATRESIA (**TA)**	**8**
5.	TRANSPOSITION OF GREAT ARTERIES **(TGA)**	**9**
6.	PARTIAL ANOMALOUS PULMONARY VENOUS CONNECTIONS (**PAPVC**)	**10**
7.	TOTAL ANOMALOUS PULMONARY VENOUS CONNECTIONS (TAPVC) • SUPRACARDIA TAPVC • INTRACARDIAC • INFRACARDIAC	**11,12,13** **11** **12** **13**
8.	DOUBLE OUTLET RIGHT VENTRICLE **(DORV)** • DORV WITH SUBAORTIC VSD • DORV WITH SUB PULMONARY VSD	**14,15** **14** **15**

Master chart

S.NO	AGE	SEX	CT NO	DURATION (since days of life)	CHIEF COMPLAINTS						CO-MORBIDITIES	ANTENATAL & BIRTH HISTORY	Operative history	ECHO FINDINGS	PROV DIAGNOSIS ON ECHO	CT ANGIOGRAPHY FINDINGS	PROV DIAGNOSIS ON CT	ECHO CORRELATION	ADDITIONAL CT CARDIAC FINDINGS	ADDITIONAL CT EXTRA-CARDIAC FINDINGS
					FAILURE TO THRIVE	CYANOSIS	TACHYCARDIA	RECURRENT URTI	LOWER LIMB EDEMA	BREATHLESSNESS										
1	0.5	M	1176400	0	-	+	+	-	-	+	Preterm	LSCS	Nil	10, 19, 25 , 29	Partial anomolous TAPVC	13,19, 23 ,25, 29	Total Infracardiac TAPVC	No	13, 23	NIL
2	0.5	M	48092	0	-	+	+	-	+	+	Low birth weight	LSCS	Nil	20,23, 29	Coarctation of aorta with ? Intrupted aortic arch (Large AVSD)	1, 19,20, 23, 29	Coarctation of aorta with intruppted aortic arch	YES	1, 19 ,23	NIL
3	60	M	223360	0	+	+	+	+	-	+	Nil	NVD	Nil	28,31	? coarctation of aorta	28,31,21	Coarctation of aorta with hypoplastc aortic arch	YES	21	length & exact course of fistula
4	16	M	1161903	0	+	+	+	+	-	+	Low birth weight,	LSCS	Operated for coarctation of aorta	34	? Hypoplastic aortc arch	34, 15	Coarctation of aorta with intruppted aortic arch	NO	15	NIL+V6
5	12	F	12991807	0	+	+	+	+	-	+	Very low birth weight	LSCS	Nil	1, 3, 35,	tricuspid atresia	1, 13, 8, 22, 24, 35,	tricuspid atresia	YES	1, 13, 22 , 24	Focal area of ground glass opacity involving left lower lobe
6	12	F	12898567	30	+	+	+	+	-	+	NIL	NVD	Nil	1, 8, 19, 28	truncus arteriosus , Ebstein anomaly	1, 8, 19, 22, 28,36	truncus arteriosus , Ebstein anomaly	YES	22, 36	Trace pleural effusions and dependent atelectasis
7	36	M	207640	0	+	+	+	+	-	+	Type 1 diabetes	NVD	Nil	1, 3, 35, 29 , 23	Single rigt ventricle with pulmonary stenosis and large atrioventircle defect	1, 3, 17, 35, 23, 24, 29	Single rigt ventricle with pulmonary stenosis and large atrioventircle defect	YES	17, 24	NIL
8	02	M	12987634	32	+	+	+	-	-	+	Nil	NVD	Nil	13	Infra cardiac TAPVC	13	Infra cardiac TAPVC	YES	0	bilateral crazy paving pattern involvement of bilateral lung Suggestive of pulmonary venous congestion
9	0.5	F	207640	0	+	+	+	-	-	+	Nil	LSCS	Nil	11, 19, 23, 25, 29	supra cardiac TAPVC	19, 23, 25 29	supra & cardiac TAPVC	YES	0	consolidation involving right middle lobe & posterobasal segment of left lower lobe
10	06	M	1180765	0	+	+	+	+	-	+	Low birth weight	NVD	Nil	13	Infracardiac TAPVC	13 , 23, 26	Infracardiac TAPVC	NO	23, 26	NIL
11	14	F	275940	60	+	+	+	+	-	+	NIL	LSCS	Nil	3, 28, 19, 9	Transposition of great vessels	1, 3, 19,23, 28 , 9	transposition of great vessels	YES	1, 23	Bilateral basal consolidations
12	06	f	10021431	0	+	+	+	+	-	+	nil	NVD	Nil	1, 3, 14, 9	Tansposition of great vessels	1, 2, 4, 3, 19, 9, 29, 30	Tansposition of great vessels	YES	2, 3, 19, 30	NIL
13	04	M	10023962	0	+	+	+	+	-	+	low weight	LSCS	Nil	1, 3, 23, 19	Pulmonary stenosis and atrial septic defect	1, 3, 23, 19 , 13	infrac cardiac Total anomolous venous connection (TAPVC)	YES	Nil	bilateral basal consolidations
14	24	F	1208958	60	+	+	+	+	-	+	Nil	NVD	Nil	1, 2, 3, 4, 28	Tetrology of fallot	1, 2, 3, 4, 22, 32,	Tetrology of fallot	YES	22, 32	NIL
15	02	M	10048242	0	+	+	+	+	-	+	low weight	LSCS	Nil	14	DORV with VSD	14, 28	DOuble otlet right ventricle with subaortic VSD	YES	23	NIL
16	12	M	200283967	0	+	+	+	+	-	+	Very low birth weight	NVD	Nil	1, 3 ,4, 22	Tetrology of fallot	1, 2, 3, 4, 22, 27, 28	Tetrology of fallot	YES	2, 27, 28	NIL
17	48	F	10013575	0	+	+	+	+	-	+	Operated for tetrology of fallot	NVD	Operated for tetrology of fallot	1, 3, 4, 5, 23, 28	Tetrology of fallot with Patent BT shunt	1, 2, 3, 4, 6, 23, 28	Tetrology of fallot with thrombosed BT shunt	NO	2, 6, 23	NIL
18	72	M	212121	60	+	+	+	+	-	+	NIL	LSCS	Nil	14, 25 , 28	Tetrology of fallot	1, 2, 3, 4, 22, 27, 28	Tetrology of fallot	yes	19, 23	NIL
19	84	M	4405114	0	+	+	+	+	+	+	Operated for tetrology of fallot	NVD	Operated for tetrology of fallot	1, 2, 4, 5 , 8, 28	Tetrology of fallot with partial trombosis of BT shunt	1, 2, 4 ,6, 8, 23, 28 , 30	Tetrology of fallot with partial trombosis of BT shunt	YES	5, 23, 30	NIL
20	120	F	7264797	30	+	+	+	+	-	+	Operated for tetrology of fallot	LSCS	Operated for tetrology of fallot	1, 2, 4, 6, 35 , 28	Tetrology of fallot Chronic with thrombosis of blalock thomas shunt	1, 2, 4, 6, 8, 23, 28 , 30, 35	Tetrology of fallot Chronic with thrombosis of blalock thomas shunt	YES	23, 30	NIL
21	48	F	10020423	240	+	+	+	+	-	+	Nil	LSCS	Nil	17,18	Single venttricle with pulmonary stenosis	1, 2, 4, 8 , 30 , 17, 19	Pulmonary stenosis	YES	30	NIL
22	48	M	7142894	120	+	+	+	+	-	+	NIL	LSCS	Nil	28, 19, 7	Truncus arteriosus	28, 3, 18, 19	Pulmonary stenosis	YES	3, 18	Nil
23	06	F	10012072	60	+	+	+	+	-	+	Nil	NVD	Nil	13, 28	Double otlet right ventricle with subaortic VSD	13, 28, 19,24	Double otlet right ventricle with subaortic VSD	YES	19, 24	bilateral basal consolidations
24	48	M	7155299	60	+	+	+	+	-	+	K/C/O tetrology of fallot	NVD	Operated for tetrology of fallot	1, 2, 3, 4, 22	tetrology of fallot wit patent shunt	1, 2, 3, 4, 23, 30	tetrology of fallot	YES	23, 30	NIL
25	120	M	1196048	60	+	+	+	+	-	+	Nil	NVD	Nil	1, 29 , 10	? TAPVC	1, 10, 20, 24, 29	Partial anomolous venous connection	YES	20, 24	NIL
26	07	M	7076642	0	+	+	+	+	-	+	Nil	LSCS	Nil	1, 2, 3, 4 , 9	Transposition of great vessels	1, 2, 3, 4, 23, 30	Tetrology of fallot	No	23	NIL
27	120	F	7066699	100	+	+	+	+	-	+	Nil	NVD	Nil	1, 3, 4 , 23	Tetrology of fallot	1, 2, 3, 4, 23	Tetrology of fallot	NO	0	NIL
28	60	M	283784	180	+	+	+	+	-	+	Nil	NVD	Nil	29, 7	Truncus arteriosus	0	NIL	YES	0	Nil

S.NO	AGE	SEX	CT NO	DURATION (since days of life)	CHIEF COMPLAINTS						CO-MORBIDITIES	ANTENATAL & BIRTH HISTORY	Operative history	ECHO FINDINGS	PROV DIAGNOSIS ON ECHO	CT ANGIOGRAPHY FINDINGS	PROV DIAGNOSIS ON CT	ECHO CORRELATION	ADDITIONAL CT CARDIAC FINDINGS	ADDITIONAL CT EXTRA-CARDIAC FINDINGS
					FAILURE TO THRIVE	CYANOSIS	TACHYCARDIA	RECURRENT URTI	LOWER LIMB EDEMA	BREATHLESSNESS										
29	12	F	295163	130	+	+	+	+	-	+	Nil	LSCS	Nil	1, 2, 3, 4	tetrology of fallot	1, 2, 3, 4, 24, 32	tetrology of fallot	YES	24, 32	NIL
30	02	F	100482421	4	+	+	+	+	-	+	Nil	NVD	Nil	27, 18	Hypoplastic left ventricle with pulmonary atresia	27, 18, 19,	Hypoplastic left ventricle with pulmonary atresia	YES	19	NIL
31	12	M	11651803	100	+	+	+	+	-	+	Nil	NVD	Nil	1, 2, 3, 4 , 28	tetrology of fallot	1, 2, 3, 4, 28 , 30	tetrology of fallot	YES	30	NIL
32	0.5	M	1199717	0	+	+	+	+	-	+	Nil	NVD	Nil	1, 19, 9, 23, 28	transposition of great vessels	1, 2, 3, 4, 28 , 30	Tetrology of fallot	NO	19, 8, 18 , 23, 28	Consolidation involving right middle lobe & posterobasal segment of left lower lobe and horseshoe kidney
33	36	M	257881	100	+	+	+	+	+	+	Nil	LSCS	Nil	1,14, 27	DORV with VSD	1, 2,14, 28	DOuble otlet right ventricle with subapulmonic VSD	YES	23, 30	NIL
34	130	M	10051727	180	+	+	+	+	-	+	K/C/O Budd chiari syndrome	LSCS	Nil	1, 2, 3, 4 , 28	tetrology of fallot	1, 2, 3, 4, 28 , 30	Tetrology of fallot	NO	0	Nutmeg liver , narrowed IVC & Collaterals , Ascites and prominet azygous & intercostal veins
35	0.5	F	10056377	7	+	+	+	+	-	+	Nil	LSCS	Nil	1, 18, 25,23, 19 , 21 , 13	double outlet right ventricle with subaortic VSD with pulmonary atresia	1, 2,, 19, 23, 21 , 37 , 13	Double aortic right ventricle with pulmonary stenosis	YES	2, 37	Consolidations bilateral lower lobes, multiple vertebral anomalies, large intraabdominal cystic area in the right illiac fossa
36	0.5	M	10055601	15	-	+	+	-	-	+	Nil	NVD	Nil	1,, 28, 19	hypoplastic left venticle with pulmonary stenosis	1, 19, 33, 28, 25, 26 , 23	hypoplastic left ventricle syndrome	YES	23, 25, 26 33	Nil
37	1.0	F	219049	0	+	+	+	+	-	+	Very low birth weight	LSCS	Nil	1 18, 19, 26, 28, 35	single ventricle with pulmonary atresia	1 18, 19, 27, 26, 28, 35	Hypoplastic left ventricle syndrome	No	23	Consolidation involving rigt lower lobe with situs inversus totalis
38	100	M	10004571	50	+	+	+	+	-	+	Operated case of tetrology of fallot	NVD	Operated case of tetrology of fallot	1,2,3,4,5 , 28	Tetrology of fallot with Patent Blalock thomas -taussig shunt	1,2,3,4,5, 23, 30	Tetrology of fallot with Patent Blalock thomas - taussig shunt	YES	23, 30	Nil
39	12	F	10043991	30	+	+	+	+	+	+	Nil	NVD	Nil	1,2,3,4, 23	Tetrology of fallot	1,2,4,28,23, 18 , 22	Tetrology of fallot	YES	22	Nil
40	24	F	1208958	180	+	+	+	+	-	+	NIL	LSCS	Nil	1,2, 18, 23	Pulmonary atresia with VSD	1, 2, 18, 23 , 27	Hypoplastic right ventricle with Pulmonary atresia with VSD	YES	8,18	Nil
41	136	F	275940	20	+	+	+	+	-	+	History of Asthma	NVD	Nil	14, 27, 28, 23	Double otlet right ventricle with subaortic VSD	14, 27, 28, 23, 19	Double otlet right ventricle with subaortic VSD	YES	19	Consolidation involving bilateral lower lobes
42	10	F	10040484	10	+	+	+	-	-	+	Nil	NVD	Nil	10, 19 , 27	Partial anomolous venous circulation	10, 19, 25, 27	Partial anomolous venous circulation	YES	25	Consolidation involving bilateral lower lobes