Journal Of Clinical Practice and Medical Case Report

Genesis-JCPMCR-1(1)-03
Volume 1 | Issue 1
Open Access

Echocardiogram Diagnosis of Acyanotic and Cyanotic Congenital Cardiac Malformations

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Citation: Maggo Christopher GL. (2024) Echocardiogram Diagnosis Of Acyanotic And Cyanotic Congenital Cardiac Malformations. J Clin Pract Med Case Rep. 1(1):1-12.

Received: January 11, 2024 | **Published**: January 26, 2024

Abstract

Background

Studies on congenital cardiac malformations in Asian-Indian children with regard to echocardiogram diagnosis of acyanotic and cyanotic cardiac defects are limited hence warranted.

Aim

The study was undertaken to determine incidence of acyanotic and cyanotic congenital cardiac defects confirmed by echocardiogram in children with relation to age and sex in pre-operative cases.

Method

A prospective study was undertaken among101children with congenital cardiac malformations attending out-patient and inpatient department at VIMS&RC and Sri Jayadeva Institute of Cardiovascular Sciences and Research of Cardiology (SJICR), Bangalore over 13 months period from March 2004 to February 2005 and July 2006. The inclusion criteria were congenital cardiac malformations in children aged 2-14 years, both male and female. Diagnosis was confirmed based on clinical examination,

laboratory investigations such as Haematocrit- Hb, Peripheral blood smear etc, Chest radiography, Electrocardiogram, Echocardiography, Real-Time Doppler echocardiography, Magnetic resonance imaging (MRI) and cardiac catheterization.

Results

Majority of two main structural types of congenital cardiac malformation were acyanotic76.23%and cyanotic 23.8%.Echocardiogram diagnosis of acyanotic cardiac defects were Atrial septal defect (ASD) 27.7%, Ventricular septal defect (VSD) 23.7%, Aortic stenosis (AS) 7.9%, Pulmonic stenosis (PS) 7.9%, Patent Ductus Arteriosus (PDA) 6.9%, Coarctation of aorta (CoA) 0.99% and Corrected Transposition of great arteries (CTGA) 0.99% while cyanotic malformations included Tetralogy of Fallot(TOF) 17.8%, Double outlet Right Ventricle (DORV) 3.9%, Pentalogy of Fallot 0.99% and Triology of Fallot 0.99%. Age distribution revealed majority 29.1% were2-4 years were predominantly 37.5% cyanotic cardiac defects and incidence of cardiac malformations decreased with increased age with 30% surviving to adolescence to less than 10% with cyanotic cardiac defects. An overall male predominance was noted including among acyanotic cardiac defects ratio ofM: F::1.2:1and M: F::1.4:1 respectively, while a female predominance was observed incyanotic cardiac defects ratio of M: F:: 0.8:1.

Conclusion

Diagnosis confirmed by echocardiogram revealed a majority 76.23%acyanoticcongenital cardiac malformation with Atrial septal defect and Ventricular septal defect together comprised 51.4%of all cardiac defects and together with Tetraology of Fallotac counted for 70% of all cardiac malformation. Majority 29% of children were aged 2-4 years with 37.5% cyanotic defects contrasted to 27% acyanotic defects. Decreased incidence of cardiac malformations with increase in age was noted and less than 10% of children with cyanotic defects survive till adolescence as opposed to 30% with cyanotic defects. An overall male predominance was noted as well as among children with cyanotic cardiac defects ratio of M: F::1.2:1 and M: F::1.4:1 respectively contrasted to female predominance ratio of M: F:: 0.8:1 in cyanotic cardiac malformations.

Keywords

Acyanotic; Teratogens; incyanotic; Ductus Arteriosus.

Introduction

The incidence of congenital cardiac malformation is reported as 4 to 50 per 1,000 live births and accounts for around 30 percent of all congenital malformation but comprises a leading cause of neonatal congenital malformations deaths [1,2]. Classification of cardiac malformations include structural types -acyanotic and cyanotic cardiac defects, abnormal formation of major blood vessels, heart valves or issues of function or position of the heart in isolation or in combination with other congenital malformations present from birth but manifest at any time after birth or may not manifest at all. Though diagnosis is usually established in the first week of life in 40-50% patients and by one month of age in remaining 50-60% of patients since congenital cardiac malformations have a wide spectrum of severity in infants, only half of these babies have abnormality severe enough to cause symptoms. Incidence from [3,4].

Incidence of critical congenital cardiac malformations of 1-2 per 1000 live births result in death requires surgical or catheter intervention within 28 days to live [5].However other study reported 12.1‰ prevalence clinically detected critical cardiac malformations [6]. Accurate diagnosis by echocardiogram confirm serious, clinically significant or clinically non-significant critical congenital cardiac malformations reported prevalence being26.6‰ severe, 3.5‰moderate, 5.4‰ mild and 17.7‰ clinically non-significant critical congenital cardiac malformations with a total prevalence being 53.2 ‰live births [7].The most common defect was VSD 17.3‰, ASD 6.2‰, PDA 1.3‰, TOF 0.4‰, Single Ventricle (SV) O.4‰,Atrio-ventricular septal defect (AVSD) 0.2‰, DORV 0.2‰.A female predominance was noted in mild defects VSD and ASD and male predominance in severe cardiac malformations. The prevalence was reduced to 19.5 ‰at fourth month follow up due to spontaneous closure of muscular VSD, PDA, ASDetc [7].Advent of screening by pulse oximetry within 48 hours of birth to assess low levels <90% oxygen saturation in peripheral blood (SpO2) as a sign of a critical cardiac malformations, report a decline by 33% infants deaths per year [10,11] identifies mainly cyanotic cardiac defects and accurate diagnosis by echocardiogram is indicated[5-7].

While a study of hospital deliveries in India estimated incidence of congenital cardiac malformations 1.12/1000births, majority 88.5% were acyanotic malformations, VSD 31.2%, PDA 24.3% being the commonest, while cyanotic malformations among 11.5%, half 48% was TOF [12]. A study from Mexico included children from one month to adolescence also reported acynotic defects 74.2% and 25.8% cyanotic cardiac defects, Patent Ductus Arterious us was commonest followed by Ventricular Septal Defect and Atrial Septal Defect [13]. In contrast a study from Turkey reported 65.1% cyanotic to 34.8% acyanotic cardiac defects [14].

Cardiac malformations are well tolerated in fetuses because of the parallel nature of the fetal circulation; even the most severe cardiac defects such as hypo plastic left heart syndrome can usually be well compensated by the fetal circulation, Cardio genesis starts in the fourth week of pregnancy as placenta is organ of gas exchange with both placental and fetal blood stream separate without mingling, however oxygen, carbon dioxide, nutrients and waste products can pass freely from one circulation to the other, as can germs or toxins, hence teratogens may not always result in cardiac abnormalities. It is believed that genetic factors play a role in the cause of these defects, but the pattern of inheritance is generally unclear. In fact, in all but about three percent of cases the underlying cause of the abnormality cannot be identified [15,16].

Material and Methods

Prospective study included 101 children with congenital cardiac malformations over a 13 months period from March 2004 to February 2005 and July 2006, ages 24 months to 14 years, both male and female attending out-patient and inpatients departments at VIMS&RC and Sri Jayadeva Institute of Cardiology, (SJIC) Bangalore. The clinical diagnosis was confirmed by clinical examination, laboratory investigations such as Haematocrit- Hb, Peripheral blood smear etc, Chest radiography, Electrocardiogram, Echocardiography, Real-Time Doppler echocardiography and cardiac catheterization.

Exclusion criteria include presence of associated chromosomal anomalies or syndromes. Chronic debilitating diseases such as tuberculosis or chronic neurological disorders of cerebral palsy, mental retardation, paralytic poliomyelitis, Endocrinal diseases such as hypothyroidism, diabetes mellitus, chronic renal diseases and obvious metabolic disorders e.g. mucopolysaccharidosis.

Results

Children with congenital cardiac malformations were divided into two main structural groups - acyanotic and cyanotic, with over three-fourths acyanotic cardiac malformations and one-fourth cyanotic cardiac malformations. The distribution of acyanotic and cyanotic cardiac malformations among 101 children shown in (Table 1) and percentage distribution of acyanotic and cyanotic cardiac malformations shown in [Figure 1].

Acyanotic Cardiac Malformation	Cyanotic Cardiac Malformation	Total
77	24	101

Table1: Distribution of children with Acyanotic and Cyanotic cardiac malformations.

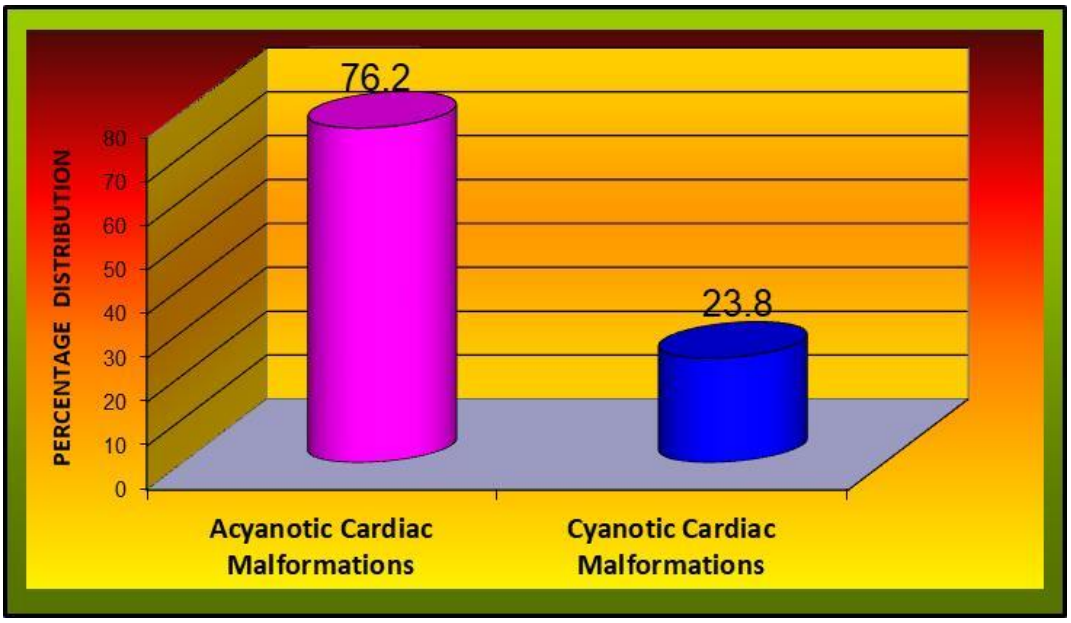

Figure 1: Percentage distribution according to Acyanotic and Cyanotic Congenital Cardiac Malformations.

Diagnosis confirmed by echocardiogram of acyanotic congenital cardiac malformations among 77 children aged 2-14 years comprised of ASD28, VSD24, AS 8, PS8, PDA 7, CoA 1 and CTGA in1 child. Among 24 children with cyanotic cardiac malformations, TOF in 18 was the commonest, other rare variants include Double outlet Right Ventricle (DORV) 4, Pentalogy of Fallot 1 and Triology of Fallot 1. Percentage distribution of congenital cardiac malformations is shown in [Figure 2].

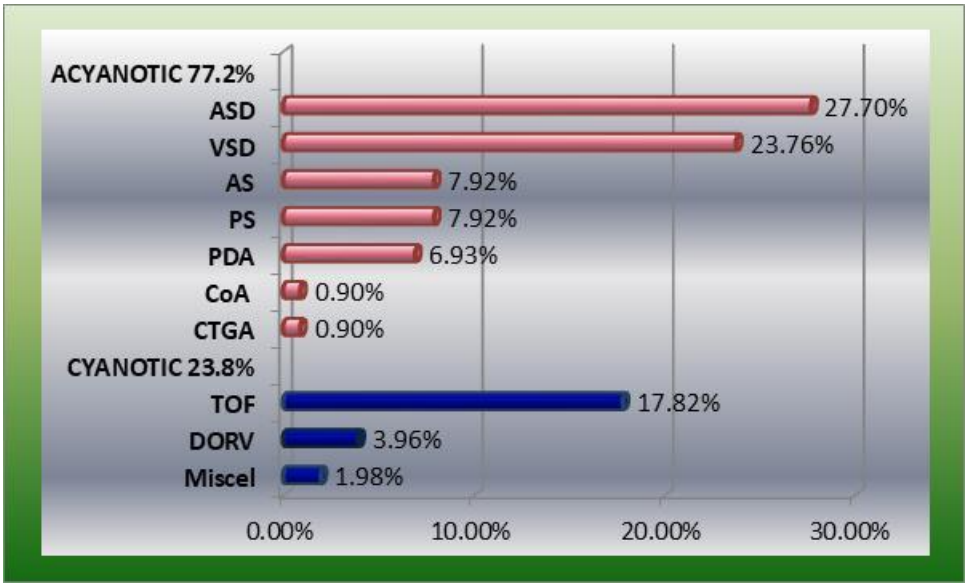

Figure 2: Percentage distribution Acyanotic and Cyanotic Congenital Cardiac Malformations

Age distribution in the present study revealed that majority 29.1% of children with cardiac malformations were toddlers 2-4 years,20.4% preschoolers 4-6 years,14.8% early childhood 6-8 years, 6.7% middle childhood 8-10 years,14.8%late childhood 10-12 years and 10.8% adolescents 12-14 years, the distribution of number of children age-wise is shown in [Figure 3].

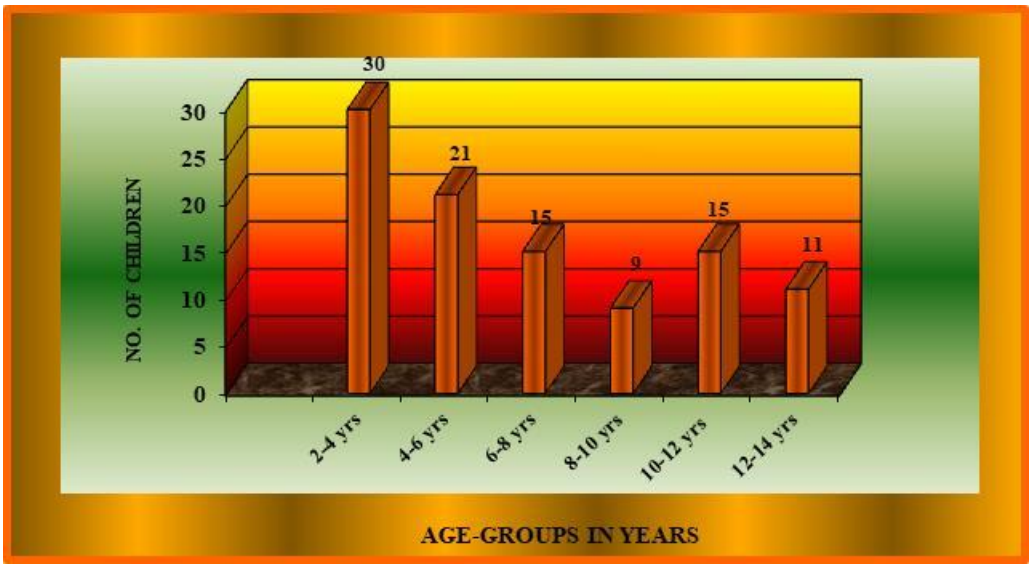

Figure 3: Age-wise distribution of number of children with congenital cardiac malformation.

Most 37.5% of toddlers aged 2-4 years presented with cyanotic cardiac contrasting to 27.2% acyanotic defects. The numbers of children with cyanotic malformations tended to decrease with increasing age, however children with acyanotic cardiac malformations revealed a decrease in ages 2-10 years, peaked

19.4% at 10-12 years, perhaps indicating better survival among acyanotic children as compared to those with cyanotic malformations who either have to be operated upon early or mortality is high in un-operable cases with poor long term survival with incidence of 12.5% among children8 - 14 years age group. Age-wise distribution of number of children with acyanotic and cyanotic cardiac malformations is shown in (Table 2) and Percentage distribution of children with acyanotic and cyanotic congenital cardiac malformations is shown in [Figure 4].

CARDIAC	AGE-WISE DISTRIBUTION OF CHILDREN						
MALFORMATIONS	2-4 yrs	4-6 yrs	6-8 yrs	8-10 yrs	10-12yrs	12-14yrs	TOTAL
	No	No.	No.	No.	No.	No.	No.
ACYANOTIC	21	15	9	8	15	9	77
CYANOTIC	9	6	6	1	-	2	24

Table 2: Age-wise distribution of children with congenital cardiac acyanotic and cyanotic malformations.

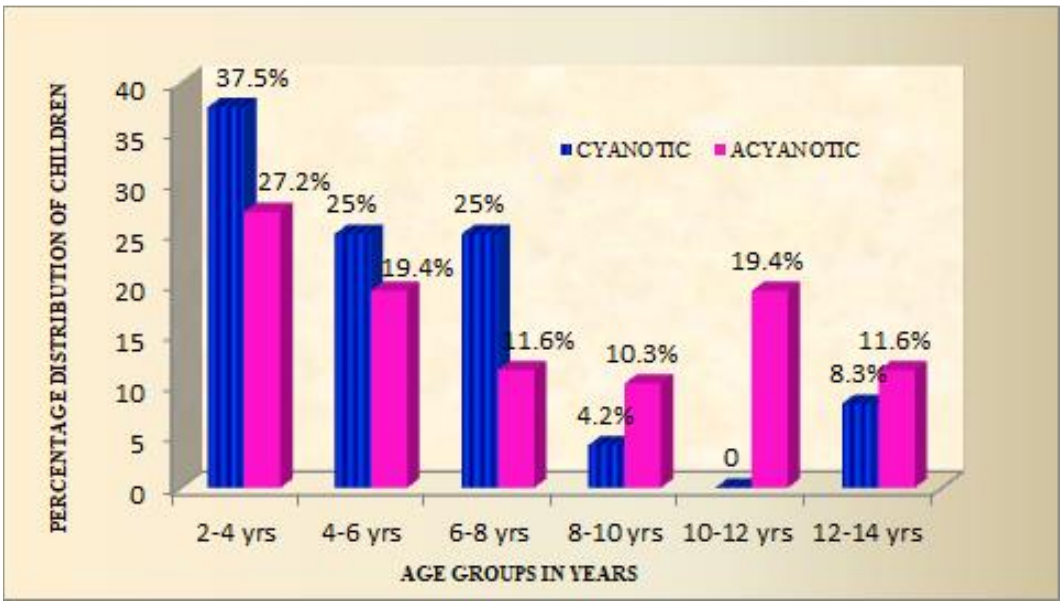

Figure 4: Percentage age-wise distribution of children with acyanotic and cyanotic congenital cardiac malformations.

The overall sex distribution of children with congenital cardiac malformations in the present study revealed male predominance of 56 males to 45 females, M: F ratio of 1.2:1. A male predominance was also noted among children with acyanotic cardiac malformations 45 males to 32 females, ratio of M: F:: 1.4:1, in contrast a female predominance was noted among cyanotic cardiac malformations 13 females to

11 males a ratio of M: F:: 0.8:1. Sex distribution of number of children with acyanotic and cyanotic congenital cardiac malformations is shown in Table 3 and percentage distribution of male and female among acyanotic and cyanotic cardiac defects is shown in [Figure 5].

Type of cardiac defect	Male	Female	Total
	No.	No	No
Acyanotic	45	32	77
Cyanotic	11	13	24
Total	56	45	101

Table 3: Sex distribution of children with acyanotic and cyanotic congenital cardiac malformations.

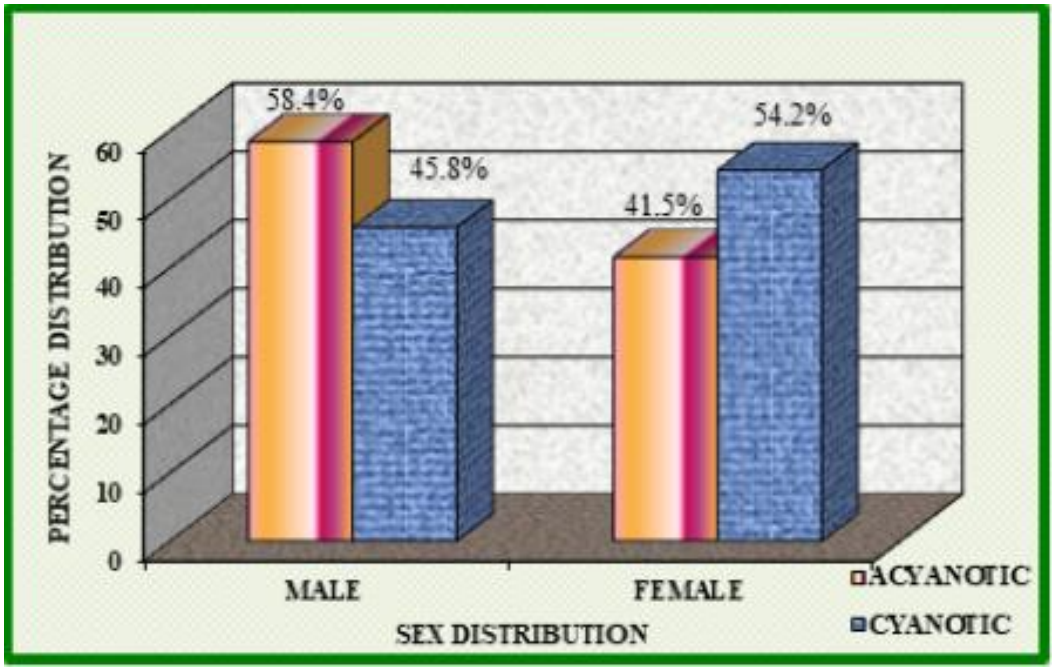

Figure 5: Sex-wise percentage distribution of Acyanotic and Cyanotic Congenital Cardiac Malformations.

Thus, there were more male children with acyanotic cardiac malformations contrasting to female predominance in those with cyanotic cardiac defects.

Discussion

Children with congenital cardiac malformations are divided into two main structural groups - acyanotic and cyanotic with signs and symptoms varying according to age and number of cardiac defects, severity and type of defect. Thus, congenital cardiac malformation in isolation or in combination present from

birth may manifest at any time after birth or may not manifest at all. In the present study 15.9% of children had complex congenital cardiac malformations with two or more combined cardiac defects. Acyanotic cardiac defects include Ventricular Septal defect, Patent Ductus Arteriosus, Atrial Septal defect, Pulmonary valve Stenosis, Aortic valve Stenosis, Coartctation of Aorta, cyanotic congenital congenital malformations include Tetralogy of Fallot, Tricuspid atresia, Transposition of great arteries, Double Outlet Right Ventricle, Total Anomalous Pulmonary Venous Drainage, Ebstein anomaly of Tricuspid valve, Truncus Arteriosus, Single ventricle and Hypo plastic left heart syndrome. Acyanotic and cyanotic congenital cardiac malformations account for 85%, the remaining 15% comprise a variety of more rare and complex cardiac lesions.

Almost all children with non-critical cardiac malformations survive the first year of life even up to adolescence, while a third live through adulthood. In contrast only three fourths with critical congenital cardiac malformations may be expected to survive one year, of which only about half will live till adolescence. Hence one in every four babies with critical cardiac malformations such as hypo plastic left heart syndrome, pulmonary atresia etc. require surgery or other interventional procedures for survival. Thus all cardiac malformations that were earlier fatal except for the most severe anomalies can be successfully treated with either medication or surgery as both palliative and corrective surgery over the last 20 years with recent advances has remarkably improved outlook for children with congenital cardiac malformations with more patients now surviving to adulthood [4,5].

The embryonic cardio genesis starts in the fourth week of pregnancy, develops into primitive ventricles as the cardiac tube gradually increases in length over the next four weeks and loops to form right and left side separated by septum develops into upper and lower chambers with four valves and truncus differentiates into their respective outflow tracts usually complete by fifth week keeps blood flowing forward and out to all parts of the body is critical to providing oxygen and nutrients to the developing embryo. The fetal circulation is independent of lungs for respiration hence there's a remarkable degree of cardiac malformations without causing difficulty as the two sides of the circulation lungs and circulatory system are separated and function on their own, placenta being the organ for gaseous and nutrient exchange in the fetus.

Blood returning from the placenta is about 80 percent saturated with oxygen. To accommodate this, the fetal heart and circulation have two special blood vessels, the ductus venosus and the ductus arteriosus, and the foramen ovale, an oval-shaped hole in the atrial septum, allowing this special circulatory pathway to operate. The ductus arteriosus is a passageway between the pulmonary artery and the aorta that allows blood to bypass the unused lungs and carry oxygen to the other organs.

At birth with ligation of the umbilical cord and initiation of the first breath, the lungs expand increasing pressure in left side of the heart resulting in closure of foramen ovale in the atrial septum, ductus arteriosus and ductus venosis with smooth transition to extra uterine life [3,4]. Thus, at birth two events occur which reorganize the circulation of the fetus. Blood stops flowing through the placenta as the umbilical cord is ligated and the gasp of the newborn baby deprived of the supply of oxygenated blood from the blood causes the lungs to expand. The pressure rises in the left side of the heart and falls in the

right, the opening - foramen ovale in the atrial septum closes by a flap forced shut by the rise in pressure in the left side. Shortly afterwards another bypass the ductus arteriosus as well as the ductus venosis also closes. The two sides of the heart are now separate units enabling the baby to make a smooth transition to extra uterine enviournment. Normally, all three of these close spontaneously within hours to days after birth.

Because of the unique communications that exist within the fetal heart and the lack of dependence upon the lungs for respiration, it is possible for fetal hearts to develop with remarkable degrees of malformation without this causing difficulty for the fetus. Such abnormalities may become important only after the fetal circulation begins its transition to the newborn state, when the two sides of the circulation become separated from each other and the lungs and circulatory system attempt to function on their own.

Teratogens may predispose to cardiac abnormalities during the critical embryonic periodsuch as maternal infections such as rubella, cytomegalovirus (CMV), toxoplasmosis, HIV or metabolic disorders of diabetes, phenylketonuria (PKU), drugs like phenytoin (Dilantin), Isotretinoin (Accutane), Lithium substance abuse of cocaine, excessive alcohol or cigarette smoking. Family risk factors is occurrences of cardiac defects in a previous child, father, or other relatives, genetic syndromes known to be associated with cardiac disease include tuberous sclerosis, Noonan syndrome, or Marfan syndrome [3,4,17-20].

Four in every ten adults with congenital cardiac malformations have cognitive disability such as lack of concentration, recall, decision making etc. Around 15% have associated genetic conditions with other physical or developmental disorders depending on how complex the cardiac defect, while over 80% with mild cardiac malformations have no developmental disabilities [21], hence screening for congenital cardiac malformations by pulse oximetry has assumed importance accounting for over one-third decline infants deaths per year from critical cardiac malformations [10,11].

In the present study the two main structural congenital cardiac malformations - acyanotic76.23% and cyanotic23.8%confirmed by echocardiogram, revealed Atrial septal defect 27.7% as the commonest cardiac defect followed by Ventricular septal defect 23.76%, Aortic stenosis 7.9%, Pulmonic stenosis 7.9%, Patent Ductus Arteriosus 6.9%, Coarctation of aorta 0.99% and Corrected Transposition of great arteries 0.99%. While cyanotic malformations defects majority were Tetralogy of Fallot 17.8% followed by Double outlet Right Ventricle 3.99 %, Pentalogy of Fallot 0.99% and Triology of Fallot 0.99%. Complex cardiac defects were present in 15.9% of 101 children raising the total number of cardiac defects in this study to 121[22].

A similar predominance of acyanotic malformations was also reported in other studies, Mumbai 82 percent [23] Mexico 74.2 percent [13] and Croatia 87.2 percent [24] contrast to study from Turkey reported predominance of cyanotic malformations 65.2 percent [14]. Incidence of acyanotic and cyanotic malformations reported in various studies shown in Table 6.

Incidence of Acyanotic and Cyanotic Cardiac Malformations

Cardiac Defect	Present study N=101	Turkey[14] N=89	Mumbai[23] N=147	Mexico[14] N=244	Croatia[24] N=222
Acyanotic	77	31	88	181	189
Cyanotic	24	58	59	63	33

The age distribution in the present study of children with congenital cardiac malformations revealed that a majority 30(29.1%) were toddlers ages 2-4 years, next 21 (20.4%) were preschoolers ages 4-6 years,15 (15.5%) early childhood 6-8 years, 9(6.7%) middle childhood 8-10 years, 15 (14-6%) late childhood 10-12 years and 11.6% adolescents 12-14 years School age children varied from 16(15.8%) in middle childhood 6-8 years age group to 9 (8.9%) in the 8-10 years group totaled. Adolescents in the 12-14 year age group comprised the remaining 12 (11.6%) an almost similar age distribution was noted in Mexico study with decline in incidence of cardiac malformations with increase in age upto adolescence.

However, the present study revealed that among toddlers aged 2-4 years had more 37.5% cyanotic defects contrasted to 27.2% children with acyanotic defects. The numbers of children with cyanotic malformations tended to decrease with increasing age, that while acyanotic malformations peaked 31% above 10 years of age, cyanotic defects decreased to 8.3% perhaps indicating better survival among acyanotic group, as the children with cyanotic malformations either have to be operated upon early or that mortality is high in un-operable cases with poor long term survival.

The overall sex distribution revealed male predominance of 57 males to 46 females, M: F ratio of 1.2:1, as well as among children with acyanotic CHD 45 males to 32 females, ratio of M: F:: 1.4:1, in contrast a female predominance was noted among cyanotic cardiac defects with 13 females to 11 males a ratio of M: F:: 0.8:1. Similarly study from Mumbai reported 65.3 percent males to 34.7 percent females, male to female ratio M:F:: 1.88:1 [23] which contrasted to a female predominance in Mexico study male 111 (45.5%) to female 133(54.5%), the male to female ratio being M:F::1:1.2 [13].

Though screening of congenital cardiac malformations by pulse oximetry at birth to detect critical cardiac malformations associated with reduction by one-third of infant deaths per year however echocardiogram gives more accurate diagnosis whether serious, clinically significant or clinically non-significant critical cardiac malformations as this study reveals less than 10% survival in children with cyanotic cardiac defects categorized as serious critical cardiac congenital malformations require early surgical intervention, acyanotic cardiac defects categorized as serious critical to mild cardiac malformations as only 30% survived up to adolescence may constitute missed diagnosis of critical congenital cardiac malformations at birth undetected by pulse oximetry.

Conclusion

A prospective study of 101 children with congenital cardiac malformations revealed majority 77.2% were acyanotic defects compared to 23.8% cyanotic defects confirmed by echocardiogram. Atrial septal defects 28.3% and Ventricular septal defects 24% were the two commonest cardiac defects accounted for half 50.6 % of all congenital cardiac defects and together with cyanotic Tetralogy of Fallot constituted 70%.

Accurate diagnosis by echocardiogram is indicated for detection of all critical cardiac malformations as this study reveals decrease incidence with increase in age of cyanotic cardiac defects less than 10% that may be detected by pulse oximetry screening at birth while acyanotic defects with only 30% survival to adolescence, constitutes missed critical cardiac malformations at birth.Majority29.1%of children were toddlers aged 2-4 years, were predominantlycyanotic37.5% cyanotic and 27.2% had acyanotic cardiac malformations. An overall male predominance was noted also in acyanotic cardiac defects contrasted to female predominance in cyanotic cardiac malformations.

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