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Comparison between Fetal Echocardiography and Neonatal Echocardiography in Diagnosing Congenital Heart Diseases

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ABSTRACT

Backgound: Congenital heart defects (CHD) are the most common congenital malformations. It is six times more common than chromosomal abnormalities and four times more common than neural tube defects. Congenital heart disease accounts for approximately 40% of perinatal deaths due to congenital anomalies and more than 20% of deaths in the first month. **Objective:** This study aimed to compare the accuracy between fetal and neonatal echocardiography in diagnosing congenital heart disease.

Patient and methods: This is a retrograde comparative study that included neonates who underwent echocardiography examination and the results were compared with fetal echocardiographic results available in historical records from prenatal care. 60 pregnant women were referred for fetal echocardiography. The included fetuses in the study were 60 fetuses. It was conducted at the Neonatal Echocardiography Unit, Pediatric Department at Zagazig University Hospitals, from July 2016 to March 2018.

Results: Our study showed that out of the 60 cases, fetal echocardiography detected 8 cases out of 24 cases diagnosed with CHD (33.3%), while Neonatal echocardiography detected 24 cases out of 24 cases diagnosed with CHD (100%).

Conclusion: The present study demonstrated that fetal cardiovascular diseases, either functional or structural, can be accurately identified by prenatal echocardiography.

Keywords: Fetal echocardiography, Neonatal echocardiography, Congenital heart diseas.

INTRODUCTION

CHDs occur in nearly 1% of live births. Being six times more common than chromosomal abnormalities and four times more common than neural tube defects. The incidence of CHD with intrauterine diagnosis ranges from 2.4% to 54%. Some countries have high incidence of CHD because they have instituted an organized policy to perform heart screening by ultrasound systematically [(1)]. Prenatal diagnosis of heart defects can lead to changes in medical management that may improve clinical outcomes. For example, decisions to deliver at tertiary care centers with ready access to paediatric medical and surgical specialties are associated with decreased neonatal morbidity and mortality. Prenatal diagnosis can be particularly important in the case of critical CHDs (those that require surgery or catheterization within the first year of life) that may cause hypoxia and lead to severe organ damage or death in the absence of timely intervention [(2)].

Although several risk factors for CHDs have been identified, such as family history, exposure to teratogenic medications, lack of prenatal vitamin and folic acid use, parenteral CHDs and pregestational diabetes, the causes of the majority of CHDs remain unexplained. However, the routine use of fetal screening echocardiography in all obstetric population is still controversial [(3)]. Various gestational ages and various methods of antenatal ultrasound assessment of fetal heart are currently available. The four-chamber view is the most basic assessment. This allows a general examination of the heart and the atrioventricular junctions. [(4)]

In addition, there is "basic" and "extended basic" fetal echocardiography which allows adequate evaluation of the outflow tracts. The overall sensitivity of fetal echocardiography ranges from 60% to 100%. Against this background, a prospective observational study was conducted between two groups of fetuses having antenatal fetal cardiac screening at multiple gestational ages for each one, comparing each result with antenatal and postnatal detailed echocardiography done by cardiologists to allow calculating its accuracy and value. [(4)]

AIM OF THE WORK

The hypothesis of this study was that echocardiography is a reliable method to diagnose congenital heart disease in fetuses and neonates.

Therefore, the purpose of this work was:

To compare the accuracy between fetal and neonatal echocardiography in diagnosing CHD.

SUBJECTS AND METHODS

Study Design:

This is a retrograde comparative study that included (60) neonates who underwent echocardiography exam and the results were compared with fetal echo results available in historical records from prenatal care. It was conducted in the Neonatal Echocardiography Unit, Pediatric Department, Zagazig University Hospitals, from July 2016 to March 2018.

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Inclusion Criteria:

All neonates were admitted to Neonatal Echocardiography Unit at Zagazig University Hospitals. Those who had available fetal records, were enrolled in the study.

Exclusion Criteria:

1. Neonates < 32 week gestational age.
2. Neonates with birth weight < 1000 g.
3. Neonates with other diagnosis, such as sepsis, or requiring ventilation.
4. Lack of prenatal care health records.
5. Lack of informed consent.

Ethical Consideration:

A written consent was obtained from parents after explanation of the procedure. **Medical Research and Ethical Committees approved the study.**

Study Protocol and Methods:

All newborns enrolled in the study were subjected to the following:

1. **Detailed prenatal, natal, and postnatal history including complete history taking:** Full maternal history taking and full neonatal data.
2. **Detailed neonatal clinical examination:** General examination and cardiac examination**.**

- **Laboratory investigations including** CBC and CRP.

3. **Neonatal echocardiography examination.**

Neonatal studies included two-dimensional, M-mode, and Doppler measurement in the standard projections: subcostal view, four-chamber view, five-chamber view, long- and short-axial parasternal views, and suprasternal view, with examination by segmental approach of the anatomy of the atriums, atrioventricular valves, ventricles, and septums. The semilunar valves, outflow tracks, and the great vessels were evaluated and flow in the ductus arteriosus was examined.

M-mode measurements were done for evaluation of left and righ ventricular dimensions, thickness and motion of the ventricular walls, left ventricular ejection fraction, and fractional shortening. M-mode recordings of the LV came from the parasternal long axis view at the middle of the mitral valve leaflet tips [(5)].

Statistical analysis:

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± standard deviation (SD).

Qualitative data were expressed as frequency and percentage. Independent-samples t-test of significance was used when comparing between two means. Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters. The confidence interval was set to 95% and the margin of error accepted was set to 5%. P-value < 0.05 was considered significant. P-value < 0.001 was considered as highly significant. P-value > 0.05 was considered insignificant.

RESULTS

Table (1): Demographic data of the studied group

Demographic Data		Mean ± SD	(Median)	(Range)
Age (days)		20.3 ± 1.8	14	(2-35)
Gestational age (weeks)		37 ± 3.3	37	(34-40)
Weight (kg)		2.9 ± 0.9	3.1	(1.1-4.5)
Length (cm)		42.8 ± 2.2	43	(40-47)
		No.	**%**	
Gender N (%)	**Males**	35	(58.3%)	
	Females	25	(41.7%)	

This table showed that this study consisted of 60 neonates with gestational age ranged from 34 to 40 weeks. Their ages ranged from 2 to 35 days and their weights ranged from 1.1 to 4.5 kgs. Their lengths ranged from 40 to 47 cm and 58.3% of the study group were males.

Table (2): Maternal obstetric history of the studied group

Maternal Data	Mean ± SD (Median) (Range)	
Maternal age (years)	36 ± 10.3 35 (20-45)	
Parity	3.2 ± 0.9 3 (1-6)	
Variable	**F (60)**	**%**
Mode of delivery		
Vaginal	18	30
Cesarean section	42	70
Indications of Cesarean section		
I-Maternal causes	42	100.0
1-Cardiac diseases	34	80.9
*Severe MS	3	7.1
*Cardomyopathy	1	33.3
2-Hypertension(pre-eclampsia)	1	33.3
3-Previous C.S	1	33.3
4-PROM	12	28.5
II-Fetal causes	15	35.7
abnormal CTG	4	9.5
	8	19.1

PROM: Premature rupture of membrane; CTG: Cardiotocography

This table showed that maternal ages ranged from 20 to 45 years old, whose parity ranged from 1 to 6 times and 70.0% of the mothers had C.S.

Table (3): Neonatal clinical data of the studied group

Variable	Frequency (60)	percentage
Respiratory distress		
Yes	7	11.7
No	53	88.3
Murmur by cardiologist		
Yes	11	18.4
*Loud harsh holosystolic:	7	63.6
*Ejection systolic murmur:	1	9.1
*Ejection systolic murmur with ejection click:	1	9.1
*Innocent murmur:	2	18.2
No	49	81.6
Cyanosis		
Yes	12	20.0
No	48	80.0
Chest X-ray		
Normal	54	90
Abnormal	6	10
*Fallot tetralogy:	2	33.3
*VSD:	3	50
*Pulmonary stenosis:	1	16.7
O2 saturation(pulse oximetry)		
<90	12	20.0
>90	48	80.0

This table showed that 11.7% of the studied neonates had RD, 18.4% had audible murmur, 20% had cyanosis, 90% had normal X-ray findings and 80.0% had normal O2 saturation.

Table (4): Neonatal Echocardiography by cardiologist in the first month of life of the studied group

Echocardiography	Frequency (60)	percentage
Normal	36	60
Congenital heart disease	24	40
VSD	8	33.3
ASD	3	12.5
PS	5	20.8
Sub-aortic membrane	1	4.2
Tricusped Atresia	3	12.5
Fallot's tetralogy	3	12.5
AS	1	4.2

This table showed that 40% of the studied neonates had congenital heart diseases by neonatal ECHO. The commonest anomaly was VSD (33.3%) followed by PS (20.8%) and ASD (12.5%).

Table (5): Comparing demographic data between normal and neonates with CHD in the studied group

Variable	CHD mean ± SD	Normal mean ± SD	t-test	p
Maternal age (years)	34.7 ± 5.6 (23-45)	23.5 ± 3.2 (20-27)	8.7	0.001**
Gestational age at birth (weeks)	36.2 ± 6.3 (34-40)	38.9 ± 1.2 (36-40)	2.5	0.01*
Body weight (kg)	2.1 ± 0.7 (1.1-3)	3.1 ± 0.9 (2.5-4.5)	4.5	0.001**

In this table, there was statistically significant difference in maternal age, gestational age at birth and body weight between diseased and normal groups.

Table (6): Comparing neonatal Echocardiography parameters by cardiologist between normal neonates and neonates with CHD in the studied group

Variable	CHD mean ± SD range	Normal mean ± SD range	t-test	P
LVSD	0.84 ± 0.13 (0.5-1.1)	0.7 ± 0.17 (0.4-1.2)	4.2	0.001**
LVISS	1.2 ± 0.2 (0.8-1.4)	0.9 ± 0.2 (0.6-1.4)	3.7	0.001**
LVIDd	2.1 ± 0.4 (1.7-2.1)	1.9 ± 0.3 (1.8-2.1)	5.5	0.001**
LVpwd	0.9 ± 0.14 (0.6-1.1)	0.8 ± 0.13 (0.6-1.1)	3.2	0.002*
LVpws	1.3 ± 0.18 (0.9-1.6)	1.1 ± 0.17 (0.8-1.4)	5.1	0.001**
EF	64.6 ± 7.6 (52-75)	62.9 ± 6.6 (54-76)	1.1	0.2
FS	35 ± 5.6 (27-45)	33.2 ± 5.2 (28-45)	1.4	0.1

In this table, there was statistically significant difference in LVSD, LVISS, LVIDd, LVIds, LVpwd and LVpws between diseased and normal groups and there was no statistically significant difference in FS and EF between diseased and normal groups.

Table (7): Predictive value of fetal ECHO by obstetrician compared to neonatal echocardiography by cardiologist in detection of CHD in the studied group

Fetal ECHO by obstetrician	NeonatalECHO by cardiologist				χ^2	P
	CHD N (24) %		Normal N (36) %			
CHD (8)	8	33.3	0.0	0.00	4.7	0.04*
Normal (52)	16	66.7	36	100		

Sensitivity = 33.3%, Specificity = 100.0%, Predictive value positive = 100.0%, Predictive value negative = 69.2% and Accuracy = 73.3%

This table showed that there was statistically significant difference between fetal and neonatal ECHO in detection of CHD. Although there was low ability of obstetrician to detect congenital heart diseases in comparison with neonatal ones by cardiologist as obstetrician could detect only 33.3% of the truly positive cases, fetal ECHO by obstetrician is a good negative test that can exclude 100.0% of the negative fetus.

DISCUSSION

Fetal echocardiography is considered beneficial for both the neonate and the family as it allows for the optimum family counseling. In addition, Arrangements for delivery at a tertiary care center where neonatal cardiac care can be made to prevent the neonatal hypoxemia and acidosis by early institution of prostaglandin E1 infusion for duct dependent lesions. Studies showed improved postnatal outcome when a prenatal diagnosis of congenital heart disease is made especially with fetal pharmacologic and catheter interventions [(6)].

The prenatal detection of CHD is fundamental for proper fetal and perinatal management. However, there was little research regarding the pharmacologic intervention for fetal CHD in Egypt. Therefore, it was vital to detect fetuses with cardiac structural or functional diseases using detailed fetal echocardiography and to plan antenatal medical treatment whenever indicated without endangering the mother's life.

During the year and half study period from July 2016 to March 2018, 60 pregnant women were referred for fetal echocardiography. The included fetuses in the study were 60 fetuses. The mean gestational age at the first fetal echocardiographic examination was 25.8 ± 3.3 weeks. This was similar to the study done by **Wieczorek and coworkers**[(6)] as the mean gestational age at diagnosis was 27.5 ± 2.5weeks**.** In another center, the average gestational age at first fetal diagnosis was 26 gestational weeks [(12)]**.** In addition, similar to our study, there was the study by **Cha *et al.*** [(7)], where the mean gestational age at diagnosis was 26.2 ± 5.2 weeks.

Because of the well developed maternal fetal medicine programs, the gestational age for referral became earlier as in the study done by Mogra *et al.* [(8)]. They showed that there is a growing body of evidence that most of the major cardiac abnormalities can be diagnosed at 14 - 15 weeks of gestation where the mean gestational age for referral was 15 ± 2 weeks**.**

In the present work, we included the cases referred for fetal echocardiography according to the American Society of Echocardiography guidelines, which divided the indications into two major divisions: fetal and maternal [(9)]**.** Recently, the American Heart Association launched the newest referral indications with three subclasses: maternal, familial and fetal indications [(10)]**.**

The most common indication for fetal echocardiography referral in the current study was maternal anemia (90%) followed by maternal hypertension (33.3%) then maternal diabetes (25%). This is in discordance with the literature that already reported a greater indication of fetal heart screening for increased nuchal translucency then accidentally discovered anomaly by obstetric ultrasound, and family history of a child with CHD [(11)]**.** Moreover, recently the statement of the American Heart Association (AHA) declared that the major reason for fetal echocardiography request is abnormal cardiac structure during the obstetric screening followed by maternal metabolic disease and family history of CHD [(11)]**.**

Similar to our results, the most common indication for fetal echo reported by **Kovavisarach and Mitinunwong** [(12)] was maternal diabetes (25.6%).

In our study, the abnormal obstetric ultrasound screen was considered irrelevant reason for fetal echocardiography. This might be attributed to the defective obstetric screening programs in Egypt especially in the outreach rural areas. In addition, some obstetricians are not completely oriented about the benefits of intrauterine diagnosis, management and their impact on fetal and neonatal outcomes. This may explain why we had no cases referred for other well-known indications like increased nuchal translucency, maternal exposure to teratogens or viral infections although these are circumstances that obstetricians frequently encounter.

In the current work, out of the 60 fetuses, 8 cases were abnormal (9.7%) and 52 were normal (90.3%). While **Cha *et al.*** [7] in a period of 3 years, they studied 313 fetuses, among them 127 fetuses were normal (40.6%) and 158 fetuses (50.6%) had structural CHD and 28 fetuses (8.8%) had functional heart diseases**.**

In the present study, we had 8 cases detected prenatally,while postnatal another 17 cases were detected (three cases with small secudum ASD, three cases with Tricusped Atresia and six cases with small apical muscular VSD and five cases with PS). These findings are consistent with the results of **Zhang** *et al.* [13] who reported that the prenatal detection rate for major structural defects was 83.3% of the structural defects. This may be explained by the fact that the structural anomalies of moderate to complex CHDs can be detected easier by fetal echocardiography. Moreover, secundum ASD, small VSD, and mild PS, are very hard to identify in the fetal period due to the nature of the normal fetal circulation and pressures. Furthermore, the neonates with normal cardiac findings on fetal echo would have mild CHDs on postnatal Echo [13] as in our study.

In many countries, if a complex heart defect is detected in a pregnancy less than 20 weeks of gestation, about half the parents choose to interrupt the pregnancy [14]**.** The same was reported in a tertiary center in Italy as 35% of cases prenatally diagnosed with CHD were terminated in 2001 and 14% of cases in 2006 [15]**.** Yet termination of pregnancy in the first trimester of pregnancy is still controversial.

In our study, on comparing the final diagnosis in the fetal echo and postnatal echo, the final diagnosis was normal in first fetal echo in 86.6% and abnormal in 13.3%. While, in the postnatal echo, it was normal in 60% and abnormal in 40%. The diagnostic accuracy varies in different studies from 85 to 99% with higher rates in recent studies which match our results [11, 16 & 17]**.** Another study found the rate of major differences to be 1.4% and minor difference 10.1% [7]**.** Such findingsare contradictory to those obtained in our study as we had 26.7% of minor differences and no major difference. This may be explained by the fact that the structural anomalies of moderate to complex CHDs can be detected by fetal echocardiography. Moreover, secundum ASD, small VSD, and mild PS, are very hard to identify in the fetal period due to the nature of normal fetal circulation. Furthermore, the neonates with normal cardiac findings on fetal echo would have mild CHDs on postnatal Echo [13] as in our study.

CONCLUSION AND RECOMMENDATION

- The present study demonstrated that fetal cardiovascular diseases, either functional or structural, can be accurately identified by prenatal echocardiography.
- Major structural heart diseases represent a major health problem because of high fetal and perinatal morbidity and mortality.
- This study raises the need of multicenter study to determine the demographic aspects of the prenatal diagnosis of CHD in Egypt.
- Further studies on larger sample of patients or multicenter researches are needed to accurately diagnose CHD and evaluate the antenatal cardiac therapy.
- Developing fetal cardiac programs in the centers of excellence are highly needed in Egypt especially in the outreach rural areas with cooperation between the different members of the team including pediatric cardiologist, obstetricians, neonatologist, geneticist, and cardiac surgeons.
- Awareness should be raised among obstetricians about the need for fetal echocardiography according to the known referral indications and the potential success of fetal cardiac therapy and about the benefits of intrauterine diagnosis, management and their impact on fetal and neonatal outcomes.

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