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Original Article

Role of ultrasound in morphologic and functional assessment of fetal heart

Radiodiagnosis

Shimaa ME. Eltohamy[1], Hany MH. Sherif [2], Fahd A. Alomda[2], Muhamed A. Al-Belehy[3], Abdullah H. Ahmed[4]

[1] Radiodiagnosis Department, Dekernes General Hospital, Dekernes, Aldakahlia, Egypt.
[2] Obstetrics and Gynecology, Faculty of Medicine for Boys, Cairo, Al-Azhar University, Egypt.
[3] Cairo Fetal Medicine Unit, Aga General Hospital, Aldakahlia, Egypt.
[4] Radiodiagnosis Department, Faculty of Medicine for Girls, Cairo, Al-Azhar University, Egypt.

ABSTRACT

Background: Congenital heart diseases represent major risk factor for infant morbidity and mortality. Accurate prenatal diagnosis may have clinical advantages for the development of the baby. Screening programs are meant to be used with the low-risk pregnant, thus they should be integrated into routine medical treatment.

Objective: To evaluate the importance of ultrasound in assessing morphology and function of fetal heart.

Methodology: A hospital based cross sectional study was conducted on 30 pregnant women who were randomly chosen and thought to have congenital cardiac problems. Aortic arch, bicaval, right and left ventricular outflow tracts, four chamber view, and three vessels view were all performed. E/A Ratio was used to evaluate the embryonic heart's functionality.

Results: The most frequent congenital cardiac disorders, according to a routine echocardiogram, were ventricular septal defect and Tetralogy of Fallot, followed by atrioventricular septal defect. One case (6.6%) of hypoplastic left heart syndrome was discovered, along with other conditions such as aortic stenosis, cardiomegaly, atrial septal defect, single ventricle, and transposition of the major arteries. All cases had an E/A ratio less than 1, with the exception of those with an atrioventricular septal defect, a single ventricle, and hypoplastic left heart syndrome, where the E/A ratio was higher.

Conclusion: Fetal heart screening must be incorporated into normal obstetric examination of cases not just for pregnant women who are at risk for congenital anomalies, but also for pregnant women without risk factors.

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Keywords: Congenital heart disease, right ventricular outflow tract, left ventricular outflow tract, 3 vessels view, aortic arch view.

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Corresponding author: Shimaa ME. Eltohamy, Radiodiagnosis department, Dekernes General Hospital, Dekernes, Aldakahlia, Egypt. Tel: 01228048827 . E-mail: dr.shimaa.eltohamy@gmail.com

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INTRODUCTION

According to estimates, the incidence of moderate to severe types of congenital heart disease (CHD) is 6–8 per 1000 live births, making it the primary cause of infant morbidity and mortality from birth abnormalities [1].

Accurate prenatal diagnosis has the potential to improve baby outcomes clinically [2]. The detection and characterization of the physiology and pathology of fetal circulation have been made possible by recent developments in ultrasound. Fetal echocardiography is being utilized to diagnose anatomical defects as well as evaluate fetal heart function. Fetal cardiology is a rapidly developing field [3].

In numerous fetal diseases, such as intrauterine growth restriction, functional echocardiography has been shown to be predictive of the outcome and to assist in the screening of high-risk groups [3].

PATIENTS AND METHODS

This hospital based cross sectional comparative study was performed on 30 pregnant women who were randomly chosen and thought to have congenital cardiac problems. The study was conducted between May 2021 and May 2022 at the Royal Fertility Center in El Mansoura. The university's ethics committee gave its approval before the study could be carried out. Prior to being enrolled in the trial, informed consent was sought from each patient.

Inclusion criteria:

- Pregnant women in their second and third trimesters of pregnancy and may have CHD.
- Pregnant women who have maternal risk factors as:
  - Metabolic disorders.
  - Familial inherited diseases.

- In vitro fertilization.
- Teratogen exposure

- **Risk factors for CHD:**
  - Abnormal cardiac examination.
  - First-degree relative of a fetus CHD.
  - Abnormal heart rate or rhythm.
  - Chromosomal anomaly of fetus.
  - Extracardiac anomaly.
  - Hydrops.
  - Increased nuchal translucency.
  - Monochorionic twins.

Exclusion criteria:
- Pregnant women in first trimester.
- Patients who refused to be included in our study.

Women involved in the study were subjected to:
1. Full history taking involving (age, parity, history of drug intake or any related medical diseases, family history of CHD)
2. Transabdominal ultrasound with two-dimension, using curvilinear transducer. The ultrasound apparatus used for the examination was the Voluson S10. It can evaluate:
   - Fetal parameters such the bi-parietal diameter, abdominal circumference, femur length, fetal number, position in the uterus; placenta position and grading; and fetal biometry.
   - Abdominal situs, including the placements of the stomach and the heart, the presence or absence of fluid in the pericardial, pleural, or peritoneal spaces.
   - By using a transverse sweep (sweep method) with cephalad motion of the transducer from fetal abdomen (at level of abdominal circumference) through the four-chamber view and towards the upper mediastinum, multiple scanning views have been carried out, including: the four-chamber view, right ventricular outflow tract (RVOT), left ventricular outflow tract (LVOT), 3Vessels view (3VV), Aortic arch view, and Bicaval view.
3. Using a typical Doppler, the fetal heart's functionality was evaluated, providing details on the heart's blood flow. Systole and diastole measurements of ventricular blood flow are possible, in addition to time interval calculations. Early diastole/ Atrial contraction (E/A) ratio evaluation was done for the diastolic function.

Statistical analysis

For accuracy and completeness, all collected data were revised. The Statistical Package for the Social Sciences (SPSS) version 16 (SPSS Inc., Chicago, Illinois, USA) was used to enter the data into the computer for statistical analysis. For quantitative data, mean and standard deviation were computed, and frequencies were determined for qualitative measures. Chi square test was used for group comparisons. It was deemed significant at $P \leq 0.05$.

RESULTS

The selected women were arranged into CHD cases (n = 15) and Normal cases (n = 15) based on whether the fetus had a CHD or a normal heart. Concerning age, it was shown that 4 cases in the CHD group were over 35 years old, compared to just 2 cases in the normal group. (Figure 1).

Regarding risk factors for CHD, about 16 cases (53.3 %) have risk factors for CHD either maternal and /or fetal risk factors for CHD. In CHD group, there were 11 cases (73.3 %) with risk factors for CHD that may be maternal or fetal or both. On the other hand, only 5 cases (33.3 %) in the normal group had risk factors for CHD. **(**$P < 0.05$**)**. Regarding the type of risk factors: in the CHD group, there are 7 cases (46.6%) with maternal risk factors, 3 cases (20%) of fetal risk factors and only 1 case (6.6%) with both risk factors. On the other hand, in the normal group: there are 3 cases (20 %) with maternal risk factors, 1 case (6.6 %) with fetal risk factor, and 1 case (6.6 %) has both risk factors (table 1).

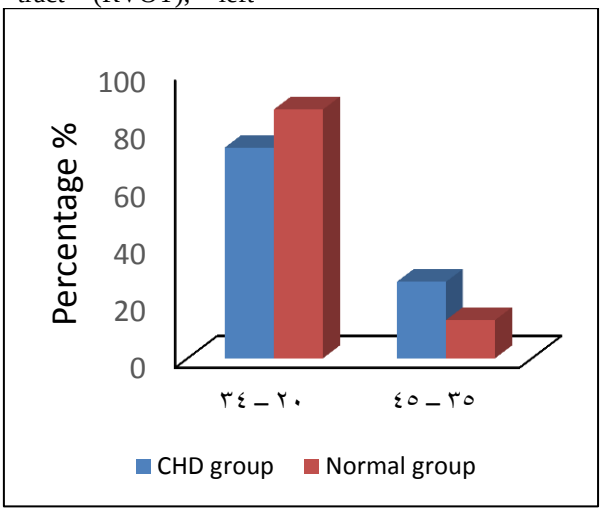

Figure (1): Age distribution among the studied patients

As regard the maternal risk factors, we revealed that age of mother > 35 years was the most common maternal risk factor as it presented in 4 cases (26.6 %) of CHD group and 2 cases (13.3 %) of normal group. The other maternal risk factors included: DM (represented by 1 case (6.6 %) in CHD group and 1 case (6.6) in the normal group), obesity (represented by only one case of CHD group), and cardiac mother (represented by only one case of CHD group). (Table 2).

The most common fetal risk factors are extracardiac disorders (presented in 2 cases (13.3 %) of CHD group) and intrauterine growth restriction (IUGR) (presented in one case of CHD group and one case of normal group) (table 3).

The results of a routine echocardiogram showed that the most frequent CHDs were VSD and TOF, which were found in 3 cases (20%) and 2 cases (13.3%), respectively. In one case (6.6%), the hypoplastic Lt heart syndrome was discovered, together with DORV, AS, cardiomegaly, ASD, a single ventricle, and transposition of major vessels (table 4).

Using conventional Doppler, fetal heart function was estimated. We assessed the E/A ratio. According to the findings, every case had an E/A ratio under 1, with the exception of those involving an AVSD, a single ventricle, and hypoplastic left heart syndrome, where the E/A ratio was greater than 1.

Table (1): Risk factors for congenital heart disease

Risk factors	CHD group (no.=15)	Normal group (no.=15)	P value
	no. (%)	no. (%)	
Maternal risk factors only	7 (46.6%)	3 (20.0%)	**0.05***
Fetal risk factors only	3 (20.0%)	1 (6.6%)	
Both maternal and fetal	1 (6.6%)	1 (6.6%)	

CHD: Congenital heart disease

Table (2): Maternal risk factors for congenital heart disease

Maternal risk factors	CHD group(no.=15)	Normal group(no.=15)	P Value
	no. (%)	no. (%)	
Age > 35	4 (26.6%)	2 (13.3%)	**0.01***
DM	1 (6.6%)	1 (6.6%)	---
Obesity	1 (6.6%)	0 (0%)	**0.05***
Cardiac	1 (6.6%)	0 (0%)	**0.05***

DM: diabetes mellitus CHD: congenital heart diseases

Table (3): Fetal risk factors for CHD

Risk factor	CHD group(no.=15)	Normal group(no.=15)	P value
	no. (%)	no. (%)	
Extracardiac anomalies	2 (13.3%)	0 (0%)	**0.01***
IUGR	1 (6.6%)	1 (6.6%)	---

IUGR: Intrauterine growth restriction

Table (4): The diagnosed CHD in our study (n= 15)

Disease	no. (%)
VSD	3 (20%)
TOF	3 (20%)
AVSD	2 (13.3%)
Hypoplastic Lt heart syndrome	1 (6.6%)
Cardiomegaly	1 (6.6%)
AS	1 (6.6%)
ASD	1 (6.6%)
DORV	1 (6.6%)
Single ventricle	1 (6.6%)
Transposition of great vessels	1 (6.6%)

AVSD: Atrioventricular septal defect, VSD: ventricular septal defect, ASD: atrial septal defect, DORV: Double outlet right ventricle, TOF: tetralogy of Fallot, AS: aortic stenosis

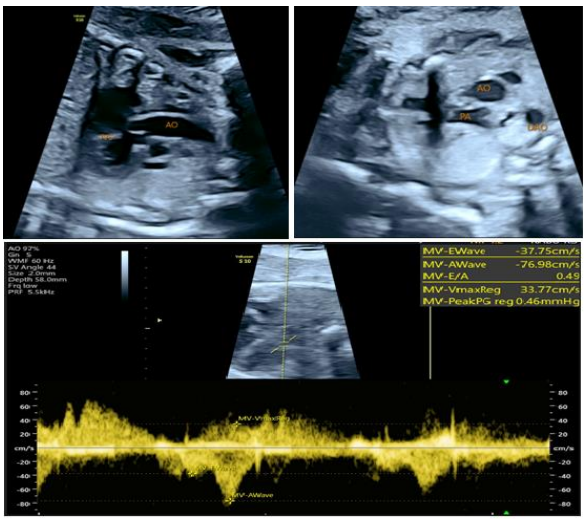

Figure (2): 38-year-old pregnant woman, G3P2, 30 weeks along in the pregnancy. HR was 144 beats per minute with the following aberrant configuration: Large ventricular septal defect (VSD) and a dilated overriding aorta are visible in the foetal heart's oblique plane at the level of the LVOT (AO). The three-vessel view (3VV) illustrates showing small sized pulmonary artery and both branches. Conventional Doppler revealed that the E/A ratio at the atrioventricular valve was less than 1. Diagnosis**:** Tetralogy of Fallot with pulmonary stenosis.

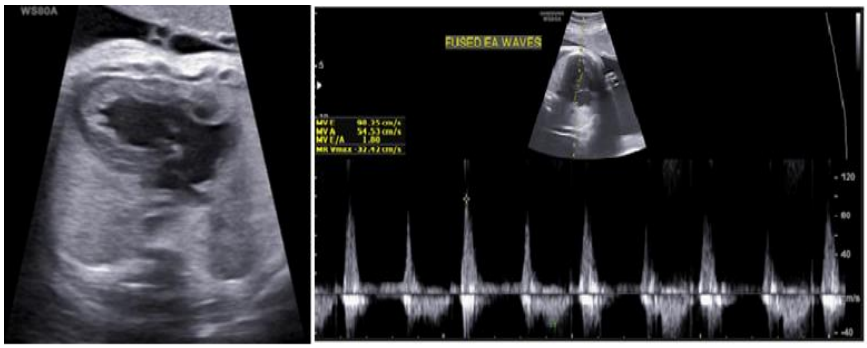

Figure (3): Routine prenatal ultrasound examination of pregnant female, 30 year old pregnant woman, G2P1, 27 week gestation. The fetus was IUGR when examined with an ultrasound. HR was 130 beats per minute with the following aberrant configuration: Inter ventriculer septum is completely absent in the four chamber view (single ventriculer cavity). Conventional Doppler revealed that the E/A ratio was greater than 1 on pulsed wave Doppler at the atrioventricular valve, which lacked any feature of an E or A wave (cannon A wave). Diagnosis: Single ventricle.

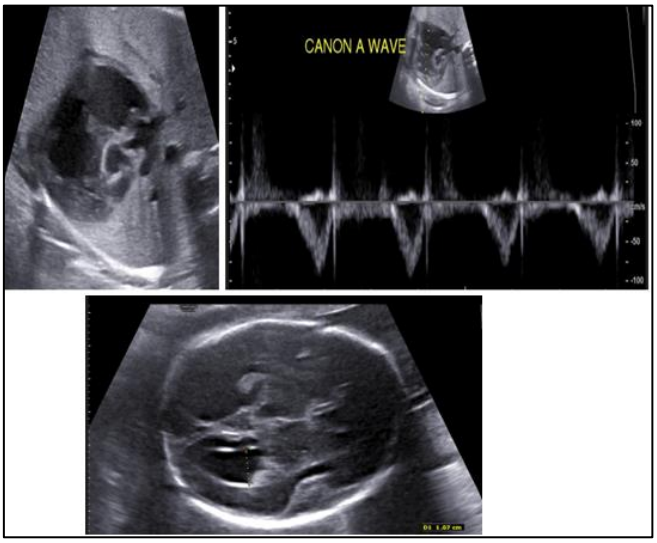

Figure (4): Routine prenatal ultrasound examination of pregnant female, 27 years old, G2P1, 28 weeks gestational age, diabetic. The US scan revealed moderate hydrocephalus, a heart rate of 145 beats per minute, and the following aberrant configuration: The foetal heart can be seen in transverse view at the level of the four chamber view, with an enlarged cardiothoracic ratio and a dilated right ventricle. In comparison to the right ventricle, the left ventricle is tiny and hypoplastic. Conventional Doppler: E/A ratio was greater than 1 on pulsed wave Doppler at the atrioventricular valve, which showed no E or A wave characteristics (cannon A wave). Diagnosis: Hypoplastic Left Heart Syndrome (HLHS).

DISCUSSION

Broadly, fetal echocardiogram is a detailed sonographic examination intended to detect and describe fetal cardiac defects prior to delivery [4].

The development of CHD was discovered to be common in fetus whose mothers were old (>35 years), as evidenced by the CHD group having 4 cases who were over 35 years old whereas only 2 cases in the normal group were over 35 years old. This was in line with the findings of Owens et al. [5] who concluded that older pregnant women had a higher incidence of CHD and that early identification during the intrauterine period was the best method for preventing it.

Our findings suggest that there is a significantly higher incidence of CHD in individuals where risk factors are present. In terms of maternal risk factors, we found that the most prevalent risk factor was a mother who was older than 35. The additional risk factors for mothers were diabetes mellitus, obesity, and cardiac mother. Extracardiac problems and IUGR are the two fetal risk factors that are most frequently present. This was in line with the findings of Al Subhi et al. [6] who discovered that maternal diabetes might have an impact on a fetus's ability to develop a heart and might result in CHD. Additionally, when compared to moms who were diagnosed with type 2 diabetes, newborns of diabetic mothers may experience higher CHD due to maternal diabetes type 1. In addition, Liu et al. [7] discovered that conditions such systemic connective tissue diseases, epilepsy, diabetes mellitus, hypertension, thyroid disorders, and multifetal pregnancy were risk factors for (CHD). According to Zhao et al. [4] infants born to moms under the age of 35 had considerably higher incidences of ventricular septal defect and atrioventricular septal defect. 9.3% of CHD cases had extracardiac abnormalities.

We discovered that VSD and TOF, then AVSD, were the most prevalent CHD in this study. As well as DORV, AS, Cardiomegaly, ASD, a single ventricle, and transposition of great vessels, hypoplastic Lt heart syndrome was also discovered in one instance. Also, hypoplastic left heart syndrome, VSD, and ASD were the most prevalent abnormalities, according to Pei et al. [9]. According to Khorshid et al. [10] the most prevalent anomaly of CHD was VSD, followed by pulmonary stenosis (PS) and ASD.

According to our findings, every case had an E/A ratio of less than 1, with the exception of those involving an AVSD, a single ventricle, and hypoplastic left heart syndrome, where the E/A ratio was greater than 1. In line with our findings, Al Subhi et al. [6] perspective's analysis discovered that HLH fetus had greater E and A velocities (p =0.01). However, a prospective investigation by Graupner et al. [11] indicated that compared to healthy fetus, the group with Hypoplastic Lt heart syndrome had significantly lower E′ velocities (p= 0.017) and E′/A′ ratios (p= 0.012) when right ventricular function was examined. A lower E/A ratio shows that atrial contraction is what drives the process of ventricular filling rather than the negative pressure experienced during relaxation.

CONCLUSION

Numbers of cardiac function markers are sensitive enough to identify high-risk patients and forecast results. The evaluation of fetal cardiac function is a promising technique that may soon be used in medical practice to diagnose, evaluate, or forecast the course of specific fetal diseases. In order to further identify precise protocols for each fetal disease that may impair cardiac function, more study is therefore required. Not only for expectant mothers who are at risk for CHD fetus, but also for mothers without risk factors, fetal heart screening must be incorporated into routine obstetric evaluation of cases. Ultrasound scanning is becoming more of a functional and quantitative modality rather than a strictly descriptive modality.

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Conflicts of Interest: The authors declare no conflicts of interest regarding the publication of this paper.

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الملخص العربي

دور الموجات فوق الصوتية في التقييم الشكلي والوظيفي لقلب الجنين

شيماء محمد المهدي التهامي[1]، هاني محمد حافظ شريف[2]، فهد عبدالعال العمدة[2]، محمد احمد البليهي[3]، عبدالله حسين احمد[4]

[1] قسم الاشعة التشخيصية، مستشفيي دكرنس العام، الدقهلية، جمهورية مصر العربية.

[2] قسم الأشعة التشخيصية، كلية طب بنين، القاهرة، جامعة الازهر، جمهورية مصر العربية.

[3] وحدة طب الجنين جامعة القاهرة، قسم النسا والتوليد، مستشفيي اجا العام، الدقهلية، جمهورية مصر العربية.

[4] قسم الأشعة التشخيصية، كلية طب بنات، القاهرة، جامعة الازهر، جمهورية مصر العربية.

ملخص البحث

الخلفية : تمثل أمراض القلب الخلقية عامل خطر رئيسي للأطفال حديثي الولادة. قد يكون للتشخيص الدقيق قبل الولادة مزايا كثيرة في نمو الطفل. تهدف برامج الفحص إلى استخدامها مع الحوامل منخفضة الخطورة، وبالتالي يجب دمجها في العلاج الطبي الروتيني

الهدف: هو معرفة دور الموجات الفوق الصوتية في التقييم الشكلي والوظيفي لقلب الجنين.

الطرق: تم إعداد هذه الدراسة المقطعية علي 30 حاله من النساء الحوامل والاتي تم اختيارهم عشوائيا والتي من المتوقع انهن لديهن اجنه مصابة بأمراض القلب الخلقية. خضعت جميع الحالات للتصوير بالموجات فوق الصوتية والتي شملت: تصوير القوس الاورطي ، مسارات التدفق البطيني الايمن والايسر، تصوير لحجرات القلب الاربعة، تصوير للأوعية الدموية الثلاثة. ايضا تم عمل تقييم لوظائف القلب باستخدام E / A.

النتائج: اكثر العيوب الخلقية انتشارا بين الحالات المصابة هي ثقب الحاجز البطيني و رباعي فالوت يليها ثقب الحاجز الاذيني البطيني. ايضا توجد حالات اخري مثل متلازمة القلب الايسر ناقص التنسج، تضخم عضله القلب، الانسداد الاورطي ومرض التغير في مكان الاوعية الدموية. نسبة E / A كانت أقل من 1 في جميع الحالات باستثناء حالات البطين الاحادي و ثقب الحاجز الاذيني البطيني و متلازمة القلب الايسر ناقص التنسج كانت نسبتهم اكثر من 1.

الاستنتاجات: يجب دمج فحص القلب للجنين في الفحص الروتيني للنساء الحوامل ليس فقط المعرضات لخطر العيوب الخلقية، ولكن أيضًا للنساء الحوامل الاتي ليس لديهم اي عوامل خطورة.

كلمات مفتاحية: العيوب الخلقية للقلب، مسارات التدفق البطيني الايمن، مسارات التدفق البطيني الايسر، تصوير الاوعية الدموية الثلاثة، تصوير القوس الاورطي.

الباحث الرئيسي

الاسم: شيماء محمد المهدي التهامي، قسم الاشعة التشخيصية، مستشفيي دكرنس العام، الدقهلية، جمهورية مصر العربية.

الهاتف: 01228048827

البريد الالكتروني: dr.shimaa.eltohamy@gmail.com