Mashhad University of Medical Sciences (MUMS)

Reviews in Clinical Medicine

Clinical Research Development Center Ghaem Hospital

Is Fetal Echocardiography Accurate Enough for Prenatal Diagnosis of Congenital Heart Diseases?

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ARTICLE INFO

Article type
Original article

Article history
Received: 08 Mar 2024
Revised: 06 May 2024
Accepted: 06 Jun 2024

Keywords
Congenital heart disease diagnosis
Fetal echocardiography
Prenatal diagnosis

ABSTRACT

Introduction: Objective: Prenatal detection of congenital heart disease (CHD) using fetal echocardiography (FE) helps in early diagnosis leading to prompt management and treatment. FE provides a highly accurate non-invasive modality to improve the survival or quality of life of CHD patients. The aim of this study was to evaluate the antenatal detection of CHD by FE and compare it with the results of postnatal echocardiography.

Methods: A prospective cohort study of pregnant women referred to a tertiary center Imam-Reza Hospital, Mashhad, Iran, for performing FE in the hands of an experienced pediatric cardiologist between 2012 and 2021. Cardiac echocardiography was performed by GE Vivid 7 color Doppler and Mindray Resona 7 color Doppler with convex probe 5-7 megahertz during late first trimester or early second trimester and after birth until 2 months later. Data were analyzed using SPSS and MedCalc software, and agreement was assessed using kappa.

Results: Out of 261 studied fetuses, 101 normal cases were detected in full agreement with postnatal echo diagnosis. Acceptable diagnosis was found for septal defects; VSDs were highly statistically detected (sensitivity= 90%, specificity= 93%).

Complex CHDs were found to be the most accurate prenatal diagnosis. Right arch anomalies, aortic stenosis, hypoplastic left heart syndrome and cardiac masses were perfectly acceptable, but detection of coarctation of the aorta faced with over-diagnosis. Prenatally diagnosed arrhythmias without structural defects, mostly premature beats, shifted to normal postnatal echo.

Conclusion: FE is a safe and sensitive modality in prenatal diagnosis of CHDs. The study showed the effectiveness accuracy of early first trimester; also complete detection in both sides of the defect spectrum.

Please cite this paper as:
Mottaghi H, Sadat Ghiasi Sh, Heidari E, Danesh L. Is Fetal Echocardiography Accurate Enough for Prenatal Diagnosis of Congenital Heart Diseases?. Rev Clin Med. 2024;11(2): 25-30.

Introduction

Congenital heart defects (CHD) are the most common congenital malformations and the leading cause of infant mortality with a prevalence of approximately 0.8% of live births, not including abortions or stillbirths. Prenatal diagnosis of congenital heart defects especially life-threatening types that require early surgical intervention improves the outcomes, decreases mortality and morbidity, including better planneddelivery in centers with trained staff centers, early specialized palliative or corrective management, and provide accurate, rapid results as early in pregnancy as possible,

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improving suitable time for the decision of treatment even pregnancy termination. CHDs differ from major critical structural abnormalities of the heart and its great vessels to small septal defects that are not never diagnosed in prenatal scans [1-6].

We assume that fetal echocardiography provides the most effective assessment for early screening and diagnosis of CHD in mid-trimester pregnancies. We do not have many choices for non-invasive prenatal diagnosis and skipping the ultrasound for screening, accessible complementary modality is fetal echocardiography; other methods such as magnetic resonance imaging (MRI) are rarely used only in specific research centers. Also, fetus movement in amniotic fluid, frequent position changes, and high heart rate require specific facilities and make it impossible to perform everywhere [7].

Parental decision-making abortion can be performed up to 16 weeks without any documentation and also termination of pregnancy due to medical reasons could be done up to 24 weeks of gestational age. But in Iran, women are allowed therapeutic abortion till the end of 18 weeks and 6 days of gestational age for special reasons such as critical CHDs and it makes early accurate prenatal diagnosis challenging an important task [6, 8-10].

The main aim of this study was to evaluate the results of the antenatal detection of CHD by fetal echocardiography and compare with post-delivery echocardiography, with a focus on critical CHD. We aimed to analyze the detection accuracy for different types of cardiac defects as well as the outcome after diagnosis in order to improve the quality of fetal cardiac screening. While the time of abortion in Iran is very limited, the importance of the problem is increasing and requires more attention . Early medical management, better planning for labor or antenatal care, hospitalization, and complication declinature should be noted. Although the prenatal diagnosis of CHDs based on fetal echocardiography in many countries assessed; to the best of our knowledge is the first study to discuss the CHD prenatal diagnosis by fetal echocardiography in comparison with after-birth echocardiography.

Materials and Method

This was a prospective cohort study that included pregnant women referred to tertiary center Imam-Reza hospital, Mashhad, Iran between 2012 and 2021. All referrals were data reviewed and standard fetal echocardiography was performed in the hands of a skilled pediatric cardiologist. More than 500 pregnant women were examined but unfortunately, parental participation in post-delivery echocardiography was very low. Eventually, 261 cases were followed up postnatally with considerable effort.

Prenatal cardiac echocardiography in the late first trimester or early second trimester was performed by expert hands using General Electric (GE) Vivid 7 color Doppler and Mindray Resona 7 color Doppler with a convex probe at 5-7 megahertz. Complete evaluation of the fetal cardiac system: four-chamber view, long-axis view of the aorta, long-axis view of the pulmonary artery, short-axis view of the ventricles and the great vessels, view of the aortic arch and ductus, also superior and inferior vena cava, determination of atrial situs, the right and left outflow tract views and the triple vessel and tracheal- views. Echocardiography is also repeated on a case-by-case basis during the neonatal period up to 2 months after birth, using the same appropriate equipment. Postnatal echocardiography of normal fetal reports was performed because of cardiac and non-cardiac soft markers, special features, cardiac murmurs, pediatrician's and parents' request. The final data were analyzed using SPSS software, and frequencies and percentages were reported. Total and relative frequencies of each type of CHD were collected along with maternal age, gestational age (GA) at referral, and fetal echocardiographic findings. Data collected in two groups, fetal and postpartum, were compared to determine accurate reporting. Variables were compared between groups using chi-squared analysis or Fisher's exact test, and agreement between methods was assessed using kappa. Again, MedCalc software was used to calculate the specificity and sensitivity of each category.

The study protocol was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (Ref: IR.MUMS.fm.REC.1394.638).

Results

Maternal age at the time of the study was (19-44)31.43±5.08 years. The mean gestational age at diagnosis by fetal echocardiography was (11-16) 2.05 weeks and newborns underwent second echocardiography at (0-418) 77.99±78.12 days.

Out of 261 fetuses examined, FECHO detected 101 normal cases, which were in complete agreement with the postnatal echo diagnosis. Abnormalities in the remaining cases are shown in Table 1. Echogenic foci diagnosed in 61 fetal hearts found to be normal on postnatal evaluation.

Table 1. Prenatal diagnosis of cardiac abnormalities versus postnatal diagnosis

Cardiac Abnormalities			Prenatal diagnosis	Postnatal diagnosis
Septal defects	Vascular septal defects	Isolated	8	10
		Non-isolated	3	9
	Atrioventricular septal defect		1	0
	Mix septal defects			
Arterial abnormalities	Patent ductus arteriosus		0	1
	Coronary Cameral fistula		1	1
Right-sided obstructive lesions	Tetralogy of Fallot		1	1
	Pulmonary valve stenosis		2	3
R.t arch abnormalities			5	3
Left-sided obstructive lesions	Aortic stenosis		1	1
	HLHS		2	2
	Coarctation of aorta		4	1
Myocardial abnormalities	Hypertrophic cardiomyopathy		2	1
	Rhabdomyoma		3	3
Complex cardiac abnormalities	Double outlet right ventricle (DORV)		1	1
	Transposition of great arteries		1	1
	TAPC		1	1
	Undefined		4	5
Minor abnormalities	Echogenic foci		61	0
Arrhythmia	Premature beats (without structural anomalies)	High-grade AV block	1	0
		SVT	1	0
		Premature Beats	6	0

Septal defects found in 20 newborns, including 8 isolated ventricular septal defects (VSDs), were diagnosed prenatally by FE, the other detected VSDs were found in combination with several associated defects at postnatal evaluation (pulmonary stenosis (PS), coarctation of the aorta, pulmonary hypertension (PH), subaortic web, patent ductus arteriosus (PDA), atrial septal defect (ASD), pulmonary atresia (PA)). Only one atrioventricular septal defect (AVSD) diagnosed in the fetus was corrected to normal. Two patients with prenatally diagnosed VSDs were converted to mild PS and bicuspid aortic valve (BAV). Three prenatally diagnosed VSDs were found to be normal after birth (sensitivity= 90%, specificity= 93%) [Table 2].

Two of nine interventricular septal defects (IVS) diagnosed by FE converted to postnatal VSDs; one of them associated with right-sided arch anomaly and the others diagnosed normal after birth. Three out of five fetal right-sided aortic arch anomalies seem to agree with postnatal (two isolated and one combined with VSD); two cases overdiagnosed prenatally; found to be normal and VSD in combination with IVS drop out, respectively (sensitivity=100%, specificity=99.22%).

One case of PDA was diagnosed after birth and one case of coronary-cameral fistula was accurately detected with complete confirmation on postnatal estimation.

The arterial channel must be open during the fetal period and its restructuring of flow, for example, due to the mother's drug use or its

Table 2. Prenatal diagnosis of ventricular septal defects in detail

Prenatal diagnosis	Postnatal diagnosis	Number of cases
Isolated VSD	Isolated VSD	8
	Non-complex, Mixed septal defects	7
	BAV	1
	Normal	3
	Mild PS	1
	Complex CHD	1
	VSD + right arch+ PS	1
VSD with associated lesions (ASD/PS/COA)	VSD	1
	Mixed septal defects	2
Normal	VSD	1
	VSD+PA	1

closure is dangerous and can cause death, so it should not be left open after birth as a prenatal diagnosis! Only in the form of news that in some cases, for example, the arterial canal was left open after birth.

Eight complex CHDs were detected seven accurately and one diagnosis with prenatal accuracy. Detection of aortic stenosis and HLHS is completely acceptable, but detection of coarctation of aorta be faced with over-diagnosis. All three cardiac masses of rhabdomyomas were detected in complete agreement with both methods.

Arrhythmias were detected in eight fetuses without structural anomalies diagnosed prenatally as premature beats, high-grade atrioventricular block, or supraventricular tachycardia that were shifted to normal on postnatal echo.

Discussion

CHD is one of the most frequently diagnosed anomalies; even in Iran it is higher than the reported universal number[11]. Prenatal diagnosis of cardiac anomalies is still a challenging issue and essential to improve survival rates and reduce complications. Approximately one third of CHDs are severe and cause high morbidity and mortality requiring intervention[12]. Due to the importance and high prevalence of CHDs, less than 30% of leading major CHDs are diagnosed early despite the implementation of sonographic pregnancy screening. Although the number in developing countries such as Iran is progressing in recent years, the majority of patients do not have prenatal diagnosis. Various causes such as unique cardiac anatomy and its motion, fetal position in the uterus, weeks of gestational age, mother's abdominal obesity and quality of using transducer affect the early examination difficulty. Reports from all over the world considered the pros and cons of prenatal detection of CHD by fetal echocardiography and showed how much benefit prenatal diagnosis could bring us. Fetal echocardiography in skilled hands can diagnose almost all important cardiac anomalies and is concluded to be a gold standard modality [13, 14].

First-trimester echocardiographic evaluation by skilled professional hands could visualize more accurate cardiac anomalies and may soon replace the routine anomaly scan between 18 and 22 weeks of gestation. Although the skill and experience of the operator is a confounding variable, the accuracy of detection by a pediatric cardiologist is even more sensitive. Our previous studies, like almost all others, showed that VSD and complex CHD are the most common cardiac anomalies; most referred by gynecologists due to abnormal sonography. We obsessed to continue working on the accuracy of fetal echocardiography, first based on comparison with sonography, which almost showed its superiority; then considered more follow-up even postnatal [8, 15].

Researchers in the neighboring country, Turkey, almost estimated the partial agreement between pre- and postnatal diagnosis of CHD and showed better statistical values than before. They related the incomplete disagreement to inadequate obtained views and late time of performed fetal echocardiography [16]. Our new study, beyond the limitations, showed almost complete agreement between prenatal and postnatal detection; accurate diagnoses were close but not complete statistical reports.

In our study a discrepancy was found between pre- and postnatal diagnosis; small or muscular VSDs, mild PS are encountered. Also, some of the existing VSDs may close spontaneously later until birth or perform immediate closure intervention after birth; this shows full confirmation with several statements that minor defects are not detectable in the prenatal study [2, 17]. Also, Al-Fahham et al. missed two cases of tiny VSDs by FE, neither of which had a critical outcome after birth [18].

IVS drop out as an instrumental restriction is mostly written to pay attention in subsequent visits when there is no definite VSD diagnosis. We detected two VSDs out of nine IVS drop out by postnatal echocardiography which it seems this issue should be considered in the next studies.

COAs cases were not perfectly diagnosed as Al-Fahham studies; aortic arch due to its left-to-right movement and then towards the spine makes a blind point even in postnatal echocardiography and mostly the diagnosis of coarctation secondary to its complications such as right heart dilation or constriction of the isthmus distinguished[18-20].

Postnatal echocardiography in fetuses with normal fetal reports only in case of sonographic abnormalities, murmur, echogenic intracardiac focus, family history and insistent request of parents showed quite complete agreement and perfect negative predictive value statistically.

FE is also the most used appropriate modality for fetal arrhythmias [21]. We detected mostly frequent premature beats, which neither had underlying structural abnormalities and resolved spontaneously in utero, as the previous evaluation considered [18, 21]. Most of the cases that presented due to arrhythmia had high gestational age and were in the second or even third trimester.

Arrhythmias are usually later and the reason

for referral in the last months of pregnancy was more common in this group.

Cardiac lesions, rhabdomyomas in our study were easily detected on prenatal echocardiograms because the fetal normal heart structure is absent [2].

In normal and complex cases, on both sides of the spectrum of cardiac anomalies, the disagreement is close to zero; show to avoid over-care follow-up normal cases and have an impact on timely and long-term care management of complex cases, leading to the improvement of survival opportunity. Detecting complex cases as early as possible in pregnancy excludes the most challenging issue of CHDs diagnosis; it could perform the rapid intervention and make therapeutic abortion when there is no way to cure and could show clear advantages [2, 18, 22-24].

Conclusion

In conclusion, fetal echocardiography is a safe and sensitive modality in prenatal diagnosis of CHDs. We concluded the effectiveness accuracy of the early first trimester of fetal echocardiography in prenatal diagnosis. It showed complete detection in both sides of the defect spectrum, also acceptable detection in the rest; although families should be informed that a normal fetal echocardiogram does not guarantee the absence of anomaly.

Strengths and limitations

Although the sample size was sufficient, it may be preferable to study in a multicenter setting to get a comprehensive view. Some fetuses lead to abortion with complex CHDs diagnoses and due to our limitation in autopsy assessment, we had to exclude them. We hope that in the future the study will proceed with more facilities.

Conflict of interest

The authors declare no competing interests.

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