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The importance of four-chamber and three-vessel (3-V) views in the screening of fetal cardiac anomalies in the first trimester

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Abstract

Objective: In this study, we aimed to investigate the efficiency of first trimester fetal heart examination.

Methods: This study was carried out prospectively on the pregnant women admitted for the screening of first trimester chromosomal anomaly to the perinatology clinic between August 2016 and February 2018. The cardiac examination was performed by obtaining abdominal situs screening and the four-chamber and three-vessel (3-V) views. The cases found to have cardiac anomaly were followed up. The patient data and results were recorded. Descriptive statistical analyses were performed.

Results: A total of 707 fetuses in 693 pregnancy cases were examined in this study. While the fetal heart examinations were performed by the transabdominal ultrasonography in 661 cases, the necessary images could not be obtained in the examinations of 32 (4.6%) cases, and the assessment was done by transvaginal ultrasonography. Abnormal cardiac findings were found in 10 cases. The diagnosis could not be validated in 3 cases and they were considered having normal hearts, and the false positivity was found in 0.4% (3/698) of the cases. The aneurysm of restrictive foramen ovale was found in two cases whose first trimester examinations were considered normal. The sensitivity, specificity, positive predictive value and negative predictive value of four-chamber and three-vessel (3-V) image for detecting the cardiac anomalies in the first trimester heart examination were 77%, 99.5%, 70% and 99.7%, respectively.

Conclusion: A great number of cardiac anomalies can be diagnosed by four-chamber and three-vessel (3-V) cross-sections in the first trimester. Also, it should be kept in mind that there may be false positivity and false negativity in the first trimester heart examinations even with low rates and some cardiac anomalies can be seen or detected only in the further weeks of gestation, and the families should be informed accordingly.

Keywords: First trimester, fetal echocardiography, four-chamber, three-vessel (3-V) view.

Özet: Birinci trimesterde fetal kalp anomalilerinin taramasında dört odacık ve üç damar (3-V) görüntüsünün önemi

Amaç: Bu çalışmada birinci trimester fetal kalp muayenesinin etkinliğinin araştırılması amaçlanmıştır.

Yöntem: Bu çalışma prospektif olarak, Ağustos 2016-Şubat 2018 tarihleri arasında perinatoloji kliniğinde, ilk trimester kromozomal anomali taraması için başvuran gebeliklerde yapıldı. Kardiyak muayene abdominal situs incelemesi, dört odacık ve üç damar (3-V) görüntüleri elde edilerek yapıldı. Kalp anomalisi saptanan olgular takip edildi. Hasta verileri ve sonuçları kayıt edildi. Tanımlayıcı istatistiksel analizler yapıldı.

Bulgular: Bu çalışmada 693 gebelik olgusunda 707 fetüs muayene edildi. 661 olguda fetal kalp muayenesi transabdominal ultrasonografi ile tamamlanırken, 32 olgunun (%4.6) muayenesinde gerekli görüntüler elde edilemedi ve transvajinal ultrasonografi ile değerlendirme yapıldı. 10 olguda anormal kalp bulgusu saptandı. Üç olguda tanı doğrulanamayarak normal kalp olarak değerlendirildi ve %0.4 (3/698) yanlış pozitiflik saptandı. Birinci trimester muayenesinde normal olarak değerlendirilen iki olguda da restriktif foramen ovale anevrizması saptandı. Birinci trimester kalp muayenesinde dört odacık, üç damar (3-V) görüntüsünün kalp anomalilerini yakalamadaki duyarlılığı %77, özgüllüğü %99.5, pozitif prediktif değeri %70 ve negatif prediktif değeri %99.7 olarak saptandı.

Sonuç: Birinci trimesterde dört odacık ve üç damar (3-V) kesitleri ile kalp anomalilerinin önemli bir kısmı tanı alabilir. Ayrıca birinci trimester kalp muayenelerinde düşük de olsa yanlış pozitiflik ve negatiflik olabileceği unutulmamalı ve bazı kalp anomalilerinin ancak gebeliğin ilerleyen haftalarında görünür veya tanınabilir olabileceği akılda tutulmalı ve aileler bu konuda bilgilendirilmelidir.

Anahtar sözcükler: Birinci trimester, fetal ekokardiyografi, dört odacık, üç damar (3-V) görüntüsü.

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Introduction

The prevalence of congenital heart diseases is 4–13 per 1000 live births, and they are one of the most important reasons of neonatal mortality and morbidity.[1] The prenatal diagnosis of cardiac anomalies is very important in the follow-up and management of both fetus and newborn, it enables to intervene in the cases properly and on time and provides a significant contribution to the prognosis.[2]

While the most of the cardiac anomalies are diagnosed in the mid-trimester, fetal echocardiography has become prevalent today with the screenings of first trimester fetal aneuploidy[3,4] and structural anomalies.[5,6] In their studies, Syngelaki et al.[6] reported the incidence of fetal anomaly 1.7% in 2019. In this study, the authors reported that they could detect 27.6% (474/1720) of all fetal anomalies and also 30.1% (117/389) of cardiac anomalies.

Hutchinson et al.[7] stated in their study that they could evaluate fetal heart anatomy to a great extent in the first trimester by using two dimensional (2D) and color Doppler ultrasonography (USG) and they reported that they could evaluate the four-chamber view in 100% of the cases by 2D and color Doppler especially in the 13 weeks of gestation, the right and left ventricle outlets in 97% of the cases by 2D USG and in 97% of the cases by color Doppler, the transposition of major arteries in 94% of the cases by 2D USG and 94% of the cases by color Doppler, the aortic arch in 94% of the cases by 2D USG and in 90% of the cases by color Doppler, and the ductal arch in 94% of the cases by 2D USG and in 94% of the cases by color Doppler. García Fernández et al.[8] reported in their study carried out with 663 pregnant women in their first trimesters that they could obtain the four-chamber view and the view of vessel outlets with the rates of 77.8–89.4% and 61.5–82.4%, respectively, by transabdominal and transvaginal ultrasonographic approach without using color Doppler ultrasonography, and that they could identify all four congenital cardiac anomalies in the first trimester.

In this study, we aimed to investigate the efficiency of the fetal echocardiography performed between 11 and 14 weeks of gestation.

Methods

This study was carried out prospectively with the pregnant women who admitted to our perinatology clinic for the screening of first trimester chromosomal anomaly between August 2016 and February 2018. The pregnant women between 11 and 14 weeks of gestation were included in our study. The weeks of gestation were determined on the basis of the last menstrual period or crown-rump length (CRL) in the cases whose last menstrual periods were unknown.

Ultrasonographic measurements and evaluations were performed by using C4-8 MHz abdominal probe and RIC 6-12 MHz vaginal probe with Voluson E10 ultrasonography device (GE Medical Systems, Zipf, Austria). The examinations were conducted by the relevant faculty member (C.Ş.) and the sub-branch specialty candidates experienced on the first trimester examination (A.Ö, H.E, F.K, Ö.K.) CRL, nuchal translucency (NT) and nasal bone measurements were done in the ultrasonographic examination, and then the fetal anatomical structures and the heart were evaluated. The cardiac examination was carried out by obtaining color Doppler images of abdominal situs, four-chamber and three-vessel (3-V) (**Figs. 1a–c**). The examination was completed by the transvaginal probe when the image quality was insufficient. All cases diagnosed in the first trimester or considered to have a pathology were re-evaluated together with pediatric cardiologist in 14–16 and 18–23 weeks of gestation.

Karyotyping by chorion villus sampling was recommended when a pathology increasing the chromosomal anomaly risk was identified. The fetuses examined in the first trimester and considered normal were re-examined in 18–23 weeks of gestation. The diagnoses were confirmed by the pediatric cardiology clinic in the postpartum period or during autopsy if they were terminated. The gestational outcomes of the cases with no pathology according to their examinations were accessed from their records in our hospital or obtained by calling their families and recorded.

Our study was supported by the Scientific Research Projects of İstanbul University (project no: 50825; May 29, 2015). The patient data were analyzed by SPSS 20 (SPSS Inc., Chicago, IL, USA). The descriptive statistical analyses (mean, standard deviation, range, percentage) were performed. The sensitivity, specificity, positive and negative predictive values and false positivity and negativity rates were calculated.

Results

A total of 693 pregnancy cases (679 singleton pregnancies, 8 dichorionic diamniotic twin pregnancies, and 6

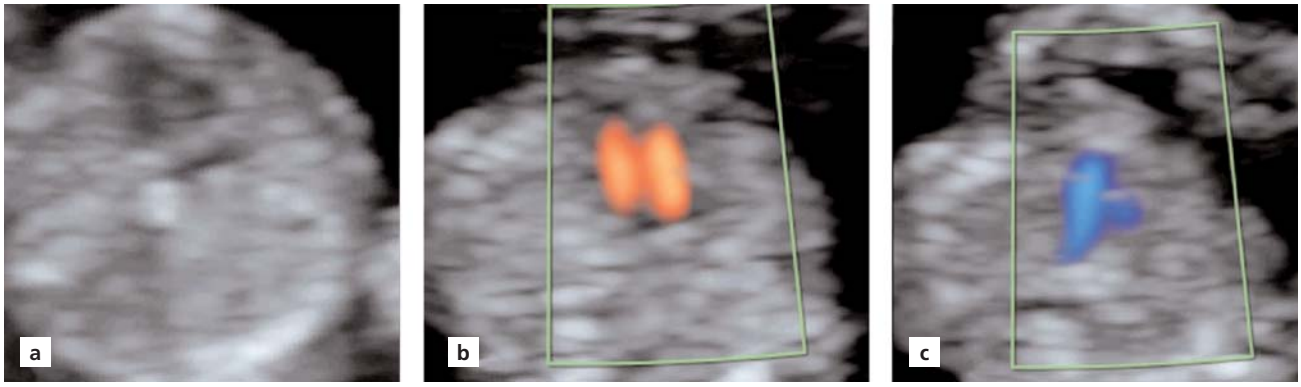

Fig. 1. (**a**) Normal four-chamber view. (**b**) Four-chamber view with color. (**c**) Three-vessel (3-V) view in color Doppler.

monochorionic diamniotic twin pregnancies) and 707 fetuses were included in our study. Mean maternal age was 30 (range: 15–46) and mean CRL was (range: 61 45–84) mm. While the fetal heart examinations of 661 cases were performed by the transabdominal ultrasonography, the necessary images could not be obtained in the examinations of 32 (4.6%) pregnancies, and the assessment was done by transvaginal ultrasonography. The examination could not be completed in 4 cases (0.6%). These four cases were examined at 16 weeks of gestation and no abnormal cardiac finding as found. Abnormal cardiac findings were found in 10 cases (**Table 1**) (right atrial isomerism and atrioventricular septal defect [AVSD] in one case (**Fig. 2**), inlet VSD in

Table 1. The cases established with the diagnosis of fetal heart disease in the first trimester examination.

Case	Record no.	Week of gestation	First trimester diagnosis	Second trimester diagnosis	Final diagnosis	Result
1	28	13 weeks and 5 days	AVSD	Normal	Normal	38 weeks and 5 days, male, 3275 g
2	96	12 weeks	Inlet VSD			Trisomy 18, termination
3	108	12 weeks and 2 days	Right isomerism, AVSD			Termination
4	128	12 weeks and 1 days	Mitral-aortic atresia hypoplastic left heart syndrome	Mitral-aortic atresia, hypoplastic left heart syndrome	Could not be accessed	45 X0, Could not be accessed
5	160	12 weeks and 6 days	Inlet VSD	Normal	Normal	41 weeks and 6 days, male, 3800 g
6	286	12 weeks	Suspected hypoplastic left heart (right-left ventricular disproportion)	Right-left ventricular disproportion (Suspected coarctation)	Follow-up for aorta coarctation	38 weeks and 5 days, male, 3615 g
7	394	12 weeks and 6 days	MAT, VSD	MAT, VSD	MAT, VSD	39 weeks, male, male, 3600 g
8	445	12 weeks and 4 days	Inlet VSD	Inlet VSD	Inlet VSD	37 weeks, male, 2740 g
9	459	13 weeks and 6 days	Tetralogy of Fallot and pulmonary valve regurgitation	Absent pulmonary valve syndrome, agenesis of ductus arteriosus, VSD, overriding aorta, right-sided aortic arch	Absent pulmonary valve syndrome, agenesis of ductus arteriosus, VSD, overriding aorta, right-sided aortic arch	36 weeks and 3 days, male, 2220 g
10	602	12 weeks and 3 days	AVSD, tricuspid valve regurgitation			Trisomy 21, termination

AVSD: Atrioventricular septal defect; **MAT:** Major artery transposition; **VSD:** Ventricular septal defect.

Fig. 2. Right isomerism AVSD (Case 3). Four-chamber view is abnormal. Single atrioventricular valve and wide VSD are present.

Fig. 3. Hypoplastic left heart syndrome (Case 4). Four-chamber view is abnormal. Left ventricle is smaller.

3 cases, mitral atresia and hypoplastic left heart syndrome (HLHS) in one case (**Figs. 3** and **4**), right-left ventricular disproportion and suspected HLHS in one case, major artery transposition (MAT) and VSD in one case (**Fig. 5**), tetralogy of Fallot (TOF) (VSD, overriding aorta) and pulmonary valve regurgitation in one case, AVSD and tricuspid valve regurgitation in one case (**Fig. 6**) and AVSD in one case. The diagnosis (TOF + pulmonary valve regurgitation) of the one of these cases was changed to absent pulmonary valve syndrome (APVS), agenesis of ductus arteriosus, VSD, overriding aorta, and right-sided aortic arch. The diagnosis in three cases (one AVSD, one inlet VSD and one suspected HLHS) could not be confirmed and considered normal

Fig. 4. Three-vessel (3-V) view of hypoplastic left heart syndrome (Case 4). Three-vessel (3-V) view is abnormal due to aortic atresia.

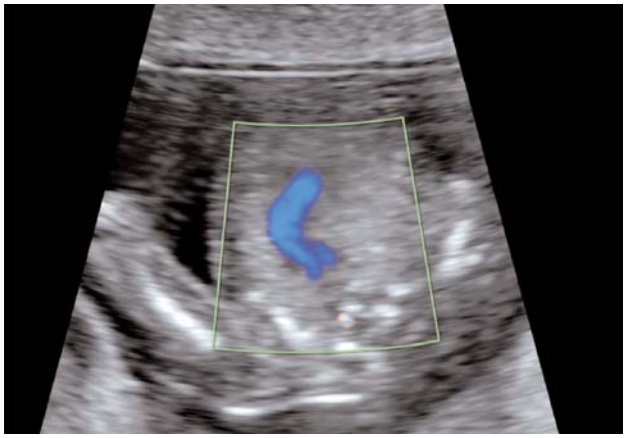

Fig. 5. Major artery transposition (Case 7). Three-vessel (3-V) view is abnormal due to major artery transposition.

Fig. 6. AVSD (Case 10). Four-chamber view is abnormal. Single atrioventricular valve and wide VSD are present.

heart, and false positivity was found 0.4% (3/698). The aneurysm of restrictive foramen ovale was detected in two cases whose first trimester examinations were found normal, and false negativity rate was found 22%. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of four-chamber and three-vessel (3-V) views for detecting cardiac anomalies in the first trimester heart examination were 77% (7/9), 99.5%, 70% and 99.7%, respectively.

Other systemic anomalies and/or genetic diseases, and congenital infections were found in 37 cases. It was confirmed by checking the autopsy or hospital records or calling cases by phone that no cardiac pathology was found in these cases. Missed abortus was identified in 5 cases and in utero mort fetus in 3 cases. It was confirmed by autopsy that in utero mort fetus cases had no cardiac pathology. The gestational outcomes of the remaining 650 cases were accessed from the hospital records or obtained by calling their families. It was confirmed that there was no pathological condition.

Discussion

The congenital heart diseases are one of the most important causes of neonatal mortality and morbidity, but the prenatal diagnosis improve gestational and newborn outcomes. Fetal echocardiography in the first trimester in particular enables the early diagnosis and management of the anomalies (such as consultancy, conducting genetic tests, early termination and case follow-up).[1,2,9]

The practicability of fetal heart examination or obtaining the cross-sections is possible in many cases, and the body mass index of pregnant woman, presence of previous surgical operation, CRL, the amount of amniotic fluid and fetal position are very important. In the study of Orlandi et al.,[10] cardiac examination could not be performed by neither transabdominal (TA) nor transvaginal (TV) approach in 141 (3.4%) cases. The authors reported that 41/686 (6%) cases in the 11 weeks of gestation, 58/1871 (3.1%) cases in the 12 weeks of gestation and 42/1614 (2.6%) cases in 13 the weeks of gestation could not be evaluated. They also stated that TV approach was required in 61 (61/4030; 1.5%) cases. We reported in our study that TV approach was required in 4.6% (32/693) cases and that we could not complete the examination of four of these cases. Persico et al.[11] conducted their study with 886 cases in the first trimester and considered 772 (87%) cases normal and 95 (10.7%) cases abnormal (with minor and major anomalies). They reported that they could not perform the examination in 19 (2.1%) cases. They reported in their study that could detect AVSD, VSD, MAT, TOF, HLHS, pulmonary atresia, cardiomegaly and disproportion between right and left ventricle dimensions in the first trimester. However, they stated that the four cases diagnosed in the second trimester were overlooked in the first trimester. When the authors reviewed the first trimester video clips of these four cases, they observed that the images of two cases were normal (partial AVSD and pulmonary stenosis in both cases) but the images of other two cases were abnormal (TOF and left atrial isomerism). They reported that 93.1% (54/58) of the major cardiac anomalies were detected in the first trimester. Weiner et al.[12] examined 200 cases with risk in the first trimester and reported that they found major cardiac anomaly (4 cases with AVSD, 1 case with VSD, 1 case with TOF, 1 case with MAT, 2 cases with truncus arteriosus, 2 cases with HLHS, and 1 case with hypoplastic right heart) in 12 cases. They also suspected major cardiac anomaly in 6 cases, and diagnosed one of these cases with TOF in the subsequent examinations and found that other five cases were normal.

Volve et al.[2] performed fetal heart examination in 4445 pregnant women in the first trimester, and followed up the patients in the second and third trimester as well as postnatal period. They found congenital cardiac anomaly in 42 (0.9%) cases. Of these cases, 39 were diagnosed prenatally and 29 (69.5%) of these 39 cases were suspected to have anomaly in the first trimester. While they confirmed the diagnosis in 27 cases, they reported that they changed the diagnosis in 2 (7%) cases (VSD – partial AVSD in one case, double outlet right ventricle [DORV] – major artery transposition in one case). They found complete AVSD, VSD, malalignment VSD, tricuspid valve dysplasia, mitral valve dysplasia, mitral stenosis, MAT, TOF, pulmonary stenosis, critical aorta stenosis, hypoplastic left heart syndrome, interrupted aortic arch, right aortic arch (RAA) and aberrant left subclavian artery (ALSA), persistent left superior vena cava, agenesis of ductus venosus and atrioventricular block anomalies in the first trimester. They considered ten cases normal in the first trimester but they diagnosed these cases with anomaly later. They found VSD in four cases, partial AVSD in one case, interrupted inferior vena cava + azygos continuation + VSD in one case, pulmonary artery stenosis in one case, TOF in one case,

aorta coarctation in one case and critical aorta stenosis in one case.

In our study, we established the diagnosis of AVSD, inlet VSD, right atrial isomerism, mitral atresia, HLHS and MAT anomalies in the first trimester. We changed the diagnosis of TOF (VSD, overriding aorta) and pulmonary valve regurgitation to absent pulmonary valve syndrome (APVS), agenesis of ductus arteriosus, VSD, overriding aorta and right-sided aortic arch in the second trimester examination in one case or added new diagnoses. However, we could not confirm the diagnoses in three cases and reported false positivity rate 0.4%. We could not identify two cases with aneurysm of restrictive foramen ovale in the first trimester and reported false negativity rate 22%. In our study, the sensitivity, specificity and positive predictive value of four-chamber and three-vessel (3-V) image for detecting the cardiac anomalies in the first trimester heart examination were 77%, 99.5%, and 70%, respectively.

Ebrashy et al.[9] prospectively assessed basically four-chamber and ventricular outlets of 3240 pregnancy cases in the first trimester and performed fetal heart examination, and they re-assessed all cases in the second trimester. They diagnosed 115 cases with or suspected of the cardiac anomaly in the first trimester. While they confirmed the diagnosis in 79 cases, they considered 36 cases normal in the second trimester and reported false positivity rate 1.2%. Also, they found cardiac anomaly in the second trimester in 17 cases who were considered normal in the first trimester, and reported false positivity rate 17.8%. They reported that 2 cases with aorta coarctation, 3 cases with MAT, 3 cases with VSD, 1 case with ARSA, 1 case with DORV, 1 case with medium pulmonary stenosis, 1 case with aorta stenosis, 1 case with RAA and 1 case with Ebstein anomaly were considered normal in the first trimester and they could not be diagnosed. Also, they investigated the efficiency of cardiac screening at 11–12 weeks and 13–14 weeks and they showed that the evaluation at 13–14 weeks would be more effective. While they found that the sensitivity was 62.5%, the specificity was 98.5% and PPD was 56.1% in the cardiac screening at 11–12 weeks, these rates were 82.3%, 98.8% and 68.7%, respectively at 13–14 weeks.

Wiechec et al.[13] also assessed 1084 cases in the first trimester and found cardiac anomaly in 35 (3.2%) cases. They reported that the sensitivity and the specificity of four-chamber view was 45.7% and 100%, respectively, and these rates were 71.4% and 100%, respectively, for three-vessel and trachea (3-VT) view. They also stated that the sensitivity of the combined approach (four-chamber + 3-VT views) was higher with a rate of 88.6%.

De Robertis et al.[14] carried out their study with 5343 pregnancy cases, and they reported that they could detect 75.8% (25/33) of the cardiac anomaly cases with four-chamber and 3-VT views in the first trimester. They found that four-chamber view was normal in 36% (9/25) of these cases and 3-VT view was normal in 16% (4/25) of these cases. They reported that they could not detect aorta coarctation in two cases, partial AVSD in two cases, TOF in one case, pulmonary stenosis in one case, RAA+ALSA in one case and rhabdomyoma in one case in the first trimester. Syngelaki et al.[6] reported that they could not detect aorta stenosis, pulmonary stenosis, truncus arteriosus, ventricular aneurysm, cardiomyopathy, rhabdomyoma and arrythmia cases although they detected all tricuspid atresia and pulmonary atresia cases in the first trimester. Also, Ficara et al.[15] highlighted that aorta coarctation, aorta stenosis, pulmonary stenosis, tricuspid valve defect and rhabdomyoma cases could be diagnosed in the third trimester.

Conclusion

In conclusion, four-chamber and three-vessel (3-V) cross-sections can be obtained and evaluated easily in the first trimester, so it is quite possible to diagnose a great number of cardiac anomalies in this period. Also, it should be kept in mind that there may be false positivity and false negativity in the first trimester heart examinations even with low rates, and that some cardiac anomalies can be seen or detected only in the further weeks of gestation, and the families should be informed accordingly.

Conflicts of Interest: No conflicts declared.

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