

The effectiveness of extended fetal echocardiography in evaluating fetal cardiac morphology

E.S. Kayaaltı¹, S. Kumbasar², B.A. Şık³

¹ Department of Obstetrics and Gynecology, Suleymaniye Research and Education Hospital, Istanbul

² Department of Obstetrics and Gynecology, Sakarya University Research and Education Hospital, Sakarya

³ Department of Obstetrics and Gynecology, İstanbul Aydın University, İstanbul (Turkey)

Summary

Purpose: To investigate the feasibility of fetal cardiac screening during routine 11-14 week scan. **Materials and Methods:** First and second trimester fetal cardiac scan was performed prospectively by sequential segmental analysis methodology in 114 fetuses within an unselected population. Fetal cardiac images were obtained by transabdominal or transvaginal approach at 11+6 – 15+2 gestational weeks at which CRL was between 52.1-98.8 mm and sections of four quadrants, three-vessel trachea, ascending aorta and aortic arch were visualized. Examination time was limited to 15 minutes. First trimester ultrasonographic views were also evaluated by another specialist in order to compare with second trimester cardiac scan and postpartum results. **Results:** Complete visualization rates were 100% (2/2), 50% (20/40), 35% (21/60), 55% (6/11), and 100% (1/1) for 11, 12, 13, 14, and 15 weeks, respectively. It was found at 44% for all gestational weeks. When aortic arch view excluded complete visualization rate, it was calculated as 74%. Satisfactory visualization was possible in 94.7% (108/114), 89.4% (102/114), 89.4% (102/114), and 58.7% (67/114) of fetuses for four chamber, three-vessels and trachea, ascending aorta and aortic arch, respectively. There was no pathologic findings in the first trimester scanning, which was concordant with second trimester and postpartum period. **Conclusions:** It is possible to obtain standard echocardiographic images and to perform fetal cardiac scan during first trimester screening. It can be recommended as a screening method for high and low risk patients in experienced hands; however, the scan must definitely be repeated at second trimester in order to detect later lesions by keeping developmental course of many cardiac defects in mind.

Key words: Extended fetal echocardiography; Transabdominal ultrasonography; First trimester.

Introduction

Congenital cardiac diseases (CCD) are the most common congenital malformations affecting six to eight in every 1,000 live births. Half of these are major abnormalities which are lethal or requiring surgery. Moreover, it is in the first place as a cause of death for newborns with congenital abnormalities [1].

Important technological developments in magnification and converting signals achieved by high frequency and high resolution transvaginal and transabdominal probes have significantly increased our ability to visualize fetal heart development in the first and second trimesters of pregnancy and enabled evaluation of fetal cardiac anatomy in this period while detecting cardiac defects.

Early fetal echocardiography has some known potential benefits. Early detection of normal cardiac anatomy in high risk patients decreases patient's concern, while early diagnosis enables safer termination of pregnancy and provides longer time for karyotyping and genetic evaluation of affected fetuses. In this way, pregnancy-related difficulties do not proceed to further weeks unnecessarily and families' sadness of losing near term or born baby may be prevented. All these reasons have stimulated perinatologists and obstetricians to detect fetal abnormalities earlier than second

trimester.

In this study, low-risk pregnant population at 11-14 gestational weeks which were admitted to the present hospital between November 2011-June 2012 underwent an extended fetal cardiac scan, and the feasibility of fetal cardiac scan was investigated by comparing with second trimester fetal cardiac scan results.

Materials and Methods

A total of 114 patients within low-risk pregnant population who were screened by extended fetal cardiac scan protocol in Suleymaniye Maternity Hospital perinatology department and who were admitted to the present hospital were included in this study. This study was planned as a type of prospective feasibility study. In all cases, sequential segmental analysis methodology was used with AB 2-7 MHz convex abdominal probe Doppler device, and with RIC 5-9 MHz vaginal probe if the images were inadequate; and first and second trimester fetal cardiac scans were performed and results were compared.

Fetuses who were 11w6d–15w2d gestational weeks old and whose CRL was between 52.1–98.8 mm at first trimester were included in this study. Then, fetal profile was obtained at neutral position and sagittal plane, and NT measurement was done. In the study, “fetal cardio” modality of obstetric applications was selected and color flow mapping (CFM) option was used for first trimester cardiac scan. Cardiac images were taken with the aid of

Revised manuscript accepted for publication June 8, 2016

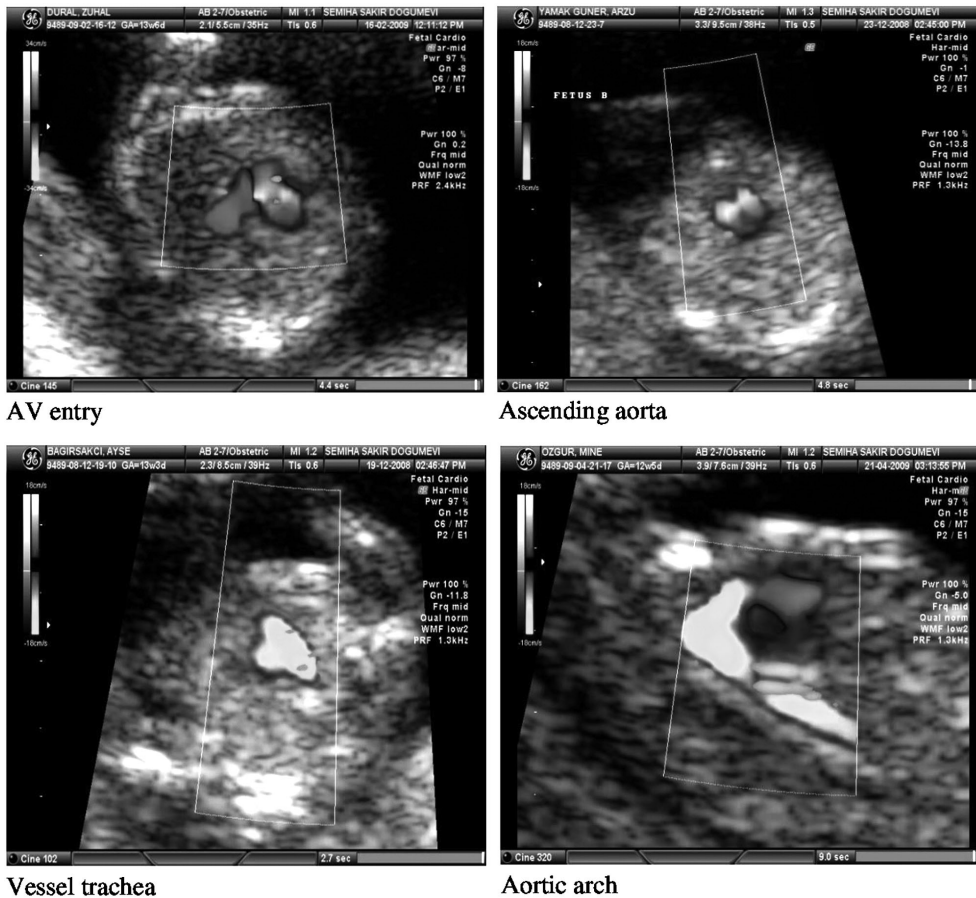


Figure 1. — AV entry, ascending aorta, vessel trachea, and aortic arch.

CFM and four quadrants (AV entry), ascending aorta, three-vessel trachea, and aortic arch were visualized (Figure 1).

During first-trimester screening, ductus venosus and tricuspid valve were evaluated in terms of Doppler flow profile. Duration of examination was limited to 15 minutes. After recording first-trimester images, quality and adequacy of the images were independently evaluated and noted by a second specialist.

Pregnant women recorded in the first trimester were requested to come for a control visit between 18 +3 – 23 +6 GW. In the second trimester, pregnant subjects underwent fetal echocardiography according to detailed fetal heart screening protocol. In addition, assessment if myocardial contractions were synchronised and rhythmical at the right and left and also in atriums and ventricles, and if there was a change in flow direction and laminar flow characteristics (aliasing) of all valves, vessels and non-pathological shunts was included. All pregnant woman subjects were called-up and postpartum results of the fetuses enrolled in the study were evaluated.

Results

One hundred fourteen low-risk pregnant women were evaluated and fetal cardiac scans were performed at first and second trimesters. It was found that there were no differences between last menstruation date (LMD) and gestational weeks that were calculated based on CRL of pregnant

women in this study, and their distribution based on gestational weeks and mean CRL is summarized in Table 1.

Maternal age was found to be 29 ± 5.88 (19-44) years and maternal age in 27 pregnancies was detected as 35 and above (24%). NT distribution of the pregnant women, who were followed up, can be seen in Table 2.

Flow patterns in ductus venosus and tricuspid valve were evaluated at first trimester; all results were observed within normal limits except the observation of inverse A wave in ductus venosus in two pregnant women. Measurements were found to be normal during the controls performed at second trimester. Four ultrasonographic sections were taken into account for pregnant women who underwent early fetal cardiac scan. Successful visualization rates based on gestational weeks are given in Table 3.

According to results of AV entry, ascending aorta, three vessel trachea and aortic arch sections, the rate of achieving complete image in all pregnant subjects was 44% by transabdominal approach (Table 4). The complete visualization rates among all pregnant women for three sections (AV entry, three vessel trachea and ascending aorta) except aortic arch was 74% with transabdominal approach.

In the present study, the authors did not detect any abnor-

Table 1. — *Distribution based on gestational weeks and mean CRL.*

Gestational weeks	Mean CRL	n = 114	%
11w0d-11w6d	51.9	2	1.7
12w0d-12w6d	59.0	40	35
13w0d-13w6d	69.4	60	52.7
14w0d-14w6d	74.3	11	9.7
15w0d-15w1d	98.8	1	0.9

Table 2. — *Mean NT based on gestational weeks.*

Gestational weeks	Mean NT
11w0d-11w6d	1.67 ± 0.41
12w0d-12w6d	1.70 ± 0.28
13w0d-13w6d	2.57 ± 0.38
14w0d-14w6d	1.70 ± 0.42
15w0d-15w1d	2.50 ± 0

Table 3. — *Successful visualization rates based on gestational weeks.*

Gestational weeks	n	AV entry n (%)	Ascending aorta, n (%)	Three-vessel trachea, n (%)	Aortic arch n (%)
11w0d-11w6d	2	2 (100)	2 (100)	2 (100)	2 (100)
12w0d-12w6d	40	36 (90)	34 (85)	37 (92.5)	28 (70)
13w0d-13w6d	60	58 (97)	55 (92)	53 (88)	28 (46)
14w0d-14w6d	11	11 (100)	10 (91)	9 (82)	8 (73)
15w0d-15w1d	1	1 (100)	1 (100)	1 (100)	1 (100)
11w0d-15w1d	114	108 (94.7)	102 (89.4)	102 (89.4)	67 (58.7)

malities at cardiac scan that was performed during early pregnancy period except hyperechogenic focus on left in three pregnancies. Genetic counseling was recommended in one of these three pregnant women since hyperechogenic focus persisted at midtrimester. No pathology was observed in the baby of the family who did not approve intervention also during postpartum period. Transvaginal examination was needed for seven in 114 patients at first trimester scan. Six of these were between 13w and 13w6d gestational weeks and one was at 12w6d gestational weeks. While aortic arch could not be visualized at high quality in six patients, three vessel trachea and ascending aorta sections could not be evaluated in one patient. No cardiac abnormality was detected during fetal cardiac scan at second trimester except hyperechogenic focus on left in four pregnancies and bilateral hyperechogenic foci in one pregnancy, increase in nuchal edema including 6.6 mm and 6 mm, tricuspid regurgitation in two pregnancies, and aberrant right subclavian artery (ARSA) and left hyperechogenic focus in one pregnancy. The authors also detected that minimal tricuspid regurgitation that was observed at 20th and 21st gestational weeks in two pregnancies regressed and disappeared at the controls during 28th gestational week and was followed up without problems during postpartum period.

Table 4. — *Number and percentages of patients who were completely imaged based on gestational weeks.*

Gestational weeks	n (%)
11w0d-11w6d	2 (100)
12w0d-12w6d	20 (50)
13w0d-13w6d	21 (35)
14w0d-14w6d	6 (55)
15w0d-15w1d	1 (100)
Total	51 (44)

Table 5. — *Comparing patients number and rates that are viewed by four quadrants and vessel exits by transvaginal approach within (11+0-13+6 GH).*

Researchers	11 GH	12 GH	13 GH
Dolkart and Reimers 1991	10 (0%)	10 (40%)	13 (38%)
Johnson <i>et al.</i> 1992	33 (0%)	51 (33%)	61 (43%)
Gembruch <i>et al.</i> 1993	15 (67%)	30 (80%)	1 (100%)
Gembruch <i>et al.</i> 2000	16 (69%)	15 (87%)	16 (100%)
Haak <i>et al.</i> 2002	85 (20%)	85 (60%)	85 (92%)
Vimpelli <i>et al.</i> 2006	53 (60%)	201 (67%)	330 (72%)

Discussion

Fetal heart is one of organs which has a high major abnormality risk and nearly 1% of all live births are complicated with CCD [2].

First trimester USG scan has become the standard practice in many countries. In general, it is performed from 11w gestational weeks until 13w6d gestational weeks for fetus number, viability, gestational week detection, and NT measurement. Fetal organogenesis is completed at late first trimester in which NT measurement is also performed. Detailed ultrasonographic examination that is performed during these weeks may aid in the diagnosis of some congenital malformations including cardiac abnormalities [3, 4]. Due to this, as well as commonly accepted relationship between NT thickness and fetal aneuploidy, prenatal diagnosis was shifted to first trimester with the developments in transducer technology used [5]. Considering that 15% of the fetuses who were detected to have cardiac malformation were accompanied by chromosomal abnormalities, early fetal echocardiography guides about early diagnosis, and genetic research [6]. Fetal echocardiography is usually performed for fetuses with a risk of CCD. On the other hand, in 50% of the babies born with CCD, unfortunately have no defined risks [7] and most of them are in observed low risk populations [8, 9]. Therefore, detailed fetal cardiac evaluation seems to be necessary for all pregnancies [10, 11].

In the beginning of 1990s until now, first studies related to transvaginal echocardiographic diagnosis of heart diseases, development of probe, and the other materials has enabled diagnosed in early stages. Transabdominal screening may be performed at earlier stages by means of technological developments in abdominal probes. Several research

groups have investigated the feasibility of early fetal echocardiography performed by transvaginal or transabdominal (or both) approaches and fetal echocardiography may safely be performed in any gestational period on.

As shown in Table 5, there is a significant increase in viewability rates by means of advancing gestational age and opportunities provided by advancing years [5, 12-16]. Also in the present study, AV entry and ascending aorta visualization rates were found to be 100% and 100% at 11th gestational weeks, 90% and 85% at 12th gestational weeks, and 95% and 92% at 13th gestational weeks, respectively. Four separate ultrasonographic sections that the present authors determined were completely observed in 44% of 114 pregnant women. This rate was found to be lower in the present study compared to previous studies; this can be explained by the exclusion of aortic arch section from those studies. The present authors' complete visualization rates for three sections (AV entry, three vessel trachea, and ascending aorta) except aortic arch was 74% in all pregnancies with transabdominal approach.

For aortic archus visualisation rate, which especially decreases at 13th GW, a value of not more than 46% may be explained by excessive fetal movements and malposition, localisation of placenta preventing visualization, time consuming false positive images, limited examination time, and non-repetitive examinations

While visualization rates of other sections were 94.7%, 89.4%, and 89.4% for AV entry, ascending aorta and three vessel trachea, respectively, since 52.7% of the pregnancies in this series were within 13th gestational weeks, this situation reflected the overall visualization rate of aortic arch, and it was found to be 58.7% that was quite low compared to the others.

In the study by Saygili *et al.*, ventricular septal defect (VSD) was shown in four cases at 13th and 14th gestational weeks. While cardiac abnormality was observed in five of 68 pregnancies (7%) in this study, this rate was found to be 15% among 26 risky pregnancies within the same group [17].

In the other studies performed, it was observed that CCD detection rates were low in low-risk population [18, 19], whereas this rate was increased in high-risk population by trained operators [20, 21]. In the present study that scanned low-risk population, any structures suggestive of abnormalities except hyperechogenic foci on left in three pregnant women were not detected during cardiac scan that was performed during early pregnancy period. Genetic counseling was recommended for one of these three pregnant women since hyperechogenic focus persisted. No pathology was seen in the baby of the family that did not approve intervention during postpartum period.

Among the pregnancies that the present authors followed, no abnormalities were detected during fetal cardiac scan at second trimester except hyperechogenic focus on left in four pregnancies and bilateral hyperechogenic foci in one preg-

nancy, increase in nuchal edema in two pregnancies, tricuspid regurgitation in two pregnancies, and aberrant right subclavian artery (ARSA), and hyperechogenic focus on left in one pregnancy. One pregnant woman accepted to undergo amniocentesis due to the increase in nuchal edema and eventually, no abnormal finding was found. There were no pathological findings during postpartum follow-ups of these pregnant women

Vimpelli *et al.* stated that standard echocardiographic images can also be obtained at 11w-13w6d gestational weeks with transvaginal approach, but they required evaluation again at later weeks [5].

Although fetal heart achieves its four-quadrant structure in the 10th week [22], a negative early period scanning does not exclude major congenital heart diseases. In addition, serious defects may appear even after second trimester. Control scanings must necessarily be performed during pregnancy especially in high risk subjects [23]. In a study by David *et al.*, it was stated that imbalance between ventricles and great vessels, which is directive especially in left ventricular and aortic outflow tract pathologies, does not appear before 22nd and mostly before 25th gestational weeks [24].

In another report that gives us an idea about the future place of early fetal echocardiography, Flidner *et al.* detected turbulent flow at aortic valve level with the aid of CFM despite completely normal appearance of four quadrants in two-dimensional B-mode image during fetal echocardiography at 11w3d gestational weeks and they made a definite diagnosis of hypoplastic left heart at the end of serial ultrasonographic examinations. Thus it has become possible to perform Norwood 1 operation to the newborn at postnatal five days [25]. In the present study, the authors observed that their early fetal echocardiography results were not misleading during the controls performed after 18th gestational weeks

In conclusion, in the present study, early fetal echocardiography results were found to be compliant with the results of that repeated at second trimester. Transabdominal approach was generally sufficient and transvaginal evaluation was required in a limited number of patients due to obesity and fetal malposition. Early fetal echocardiography provides parents the option of early decision-making regarding the babies with severe fetal abnormalities. By this way, it is aimed to decrease the number of late therapeutic abortions. Early fetal echocardiography can be offered as a screening method to high- and low-risk patients in experienced hands; however, in case that the screening is normal, it should be repeated at second trimester in order to detect possible lesions that may develop in later periods.

References

- [1] Bernstein D.: "Congenital heart diseases". In: Behrman R.E., Kliegman R.M., Jenson H.B., Stanton B.F. (eds). *Nelson Textbook of Pediatrics*. 18th ed. Philadelphia: WB Saunders Company, 2007, 1878.

- [2] Allan L.D., Sharland G.K., Milburn A., Lockhart S.M., Groves A.M.M., Anderson R.H., *et al.*: "Prospective diagnosis of 1006 consecutive cases of congenital heart disease in the fetus". *J. Am. Coll. Cardiol.*, 1994, 23, 1452.
- [3] Whitlow B.J., Chatzipapas I.K., Lazanakis M.L., Kadir R.A., Economides D.L.: "The value of sonography in early pregnancy for the detection of fetal abnormalities in an unselected population". *Br. J. Obstet. Gynaecol.*, 1999, 106, 929.
- [4] Haak M.C., Bartelings M.M., Gittenberger-De Groot A.C., van Vugt J.M.: "Cardiac malformations in first-trimester fetuses with increased nuchal translucency: ultrasound diagnosis and post-mortem morphology". *Ultrasound Obstet. Gynecol.*, 2002, 20, 14.
- [5] Vimpelli T., Huhtala H., Acharya G.: "Fetal echocardiography during routine first-trimester screening: a feasibility study in an unselected population". *Prenat Diagn.*, 2006, 26, 475.
- [6] Lin A.E.: "Congenital heart defects in chromosome abnormality syndromes". In: Emmanouilides G.C., Allen H.D., Reimenschneider T.A., Gutgesell H.P. (eds). *Heart disease in infants, children, and adolescents*. Baltimore: Williams & Wilkins, 1995, 633.
- [7] Ayres N.A.: "Advances in fetal echocardiography". *Tex. Heart Inst. J.*, 1997, 24, 250.
- [8] Stumpflen I., Stumpflen A., Wimmer M., Bernaschek G.: "Effect of detailed fetal echocardiography as part of routine prenatal ultrasonographic screening on detection of congenital heart disease". *Lancet*, 1996, 348, 854.
- [9] Copel J.A., Pilu G., Green J., Hobbins J.C., Kleinman C.S.: "Fetal echocardiographic screening for congenital heart disease: the importance of the four chamber view". *Am. J. Obstet. Gynecol.*, 1987, 157, 648.
- [10] Carvalho J.S., Mavrides E., Shinebourne E.A., Campbell S., Thilaganathan B.: "Improving the effectiveness of routine prenatal screening for major congenital heart defects". *Heart*, 2002, 88, 387.
- [11] Sharland G.: "Routine fetal cardiac screening: what are we doing and what should we do?" *Prenat. Diagn.*, 2004, 24, 1123.
- [12] Johnson P., Sharland G., Maxell D., Allan L.: "The role of transvaginal sonography in the early detection of congenital heart disease". *Ultrasound Obstet. Gynecol.*, 1992, 2, 248.
- [13] Gembruch U., Knopfle G., Bald R., Hansmann M.: "Early diagnosis of fetal congenital heart disease by transvaginal echocardiography". *Ultrasound Obstet. Gynecol.*, 1993, 3, 310.
- [14] Dolkart L.A., Reimers F.T.: "Transvaginal fetal echocardiography in early pregnancy: normative data". *Am. J. Obstet. Gynecol.*, 1991, 165, 688.
- [15] Gembruch U., Shi C., Smrcek J.M.: "Biometry of the fetal heart between 10 and 17 weeks gestation". *Fetal Diagn. Ther.*, 2000, 15, 20.
- [16] Haak M.C., Twisk J.W., van Vugt J.M.: "How successful is fetal echocardiographic examination in the first trimester of pregnancy?" *Ultrasound Obstet. Gynecol.*, 2002, 20, 9.
- [17] Saygılı A., Yılmaz E., Barutçu Ö., Tokel K.: "Fetal kalbin değerlendirilmesinde transvaginal ekokardiografinin etkinliği". *Perinatoloji Dergisi*, 2001, 9, 235.
- [18] Buskens E., Grobbee D.E., Frohn-Mulder I.M., Stewart P.A., Juttman R.E., Wladimiroff J.W., Hess J.: "Efficacy of routine fetal ultrasound screening for congenital heart disease in normal pregnancy". *Circulation*, 1996, 94, 67.
- [19] Garne E., Stoll C., Clementi M., Euroscan Group: "Evaluation of prenatal diagnosis of congenital heart diseases by ultrasound: experience from 20 European registries". *Ultrasound Obstet. Gynecol.*, 2001, 17, 386.
- [20] Yagel S.I., Weissman A., Rotstein Z., Manor M., Hegesh J., Anteby E., *et al.*: "Congenital heart defects: Natural course and in utero development". *Circulation*, 1997, 96, 550.
- [21] Comas Gabriel C., Galindo A., Martinez J.M., Carrera J.M., Gutiérrez-Larraya F., de la Fuente P., *et al.*: "Early prenatal diagnosis of major cardiac anomalies in a high risk population". *Prenat. Diagn.*, 2002, 22, 586.
- [22] Moore K.L., Persaud T.V.N.: "The developing human: clinically oriented embryology". 6th ed. Philadelphia: WB Saunders, 1998, 349.
- [23] Yagel S., Cohen S.M., Messing B.: "First and early second trimester fetal heart screening". *Curr. Opin. Obstet. Gynecol.*, 2007, 19, 183.
- [24] David N., Iselin M., Blaysat G., Durand I., Petit A.: "Desequilibre dans la diametre des cavites cardiaques et vaisseaux chez le foetus". *Arch. Mal Coeur Vaiss.*, 1997, 90, 673. [Article in French]
- [25] Axt-Flidner R., Kreiselmaier P., Schwarze A., Krapp M., Gembruch U.: "Development of hypoplastic left heart syndrome after diagnosis in the first trimester by early fetal echocardiography". *Ultrasound Obstet. Gynecol.*, 2006, 28, 106.

Corresponding Author:

S. KUMBASAR, M.D.

Department of Obstetrics and Gynecology,

Sakarya University Research and Education Hospital

Sakarya 54000 (Turkey)

e-mail: doktor1977@hotmail.com