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How much can we evaluate fetal anatomy at 11–13+6 weeks of gestation?

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Abstract

Objective: The aim is to determine how much fetal anatomic structures can be displayed according to different CRL values in addition to the aneuploidy screening at 11–13+6 weeks which is a part of routine gestational examination.

Methods: In the study planned to be as retrospective descriptive case series, we analyzed the data of a total of 5238 single fetuses which had nuchal screening at 11–13+6 weeks of gestation between April 1, 2006 and September 30, 2017. We separated fetuses into 4 groups according to the CRL measurements (Group 1: CRL between 45 and 54 mm, Group 2: CRL between 55 and 64 mm, Group 3: CRL between 65 and 74 mm, and Group 4: CRL between 75 and 84 mm). For each group, we calculated imaging rates of organ and body parts of fetuses and carried out statistical analyses.

Results: The mean age of pregnant women was 30.1±4.65 (range: 17 to 46) years, and median CRL value of fetuses was 62 (range: 45 to 84) mm. In all groups, the organs and parts with the highest success of fetal anatomy imaging were upper extremity, lower extremity, cranium, stomach, bladder, nuchal translucency, nasal bone, vertebra and abdomen, respectively. The imaging rate for all of these structures was above 90%. A four-chambered heart could be identified in 52.6% of all groups, and cardiac outflow tracts were seen in 44.3% of all groups. It was found that kidneys were seen in 52.0% of all groups. Among CRL groups, imaging rates of all anatomic structures except cranium, nuchal translucency, abdominal wall and lower and upper extremities had statistically significant difference. While Group 1 had the lowest imaging rates, Group 4 had the highest rates.

Conclusion: In our study, we found that basic fetal anatomic structures except heart and kidneys can be seen with a success rate over 90% during aneuploidy screening at 11–13+6 weeks of gestation, and as expected the imaging rates were increased parallel to the gestational week. Although the timing of the nuchal screening is favorable at 11th to 12th weeks classically, for the evaluation of fetal anatomy, 12th to 13th week are preferable.

Keywords: 11–13 weeks of gestation, fetal anatomy, ultrasonography, imaging success, first trimester, fetal heart.

Özet: 11–13+6 haftada fetal anatomiyi ne kadar değerlendirebiliriz?

Amaç: Rutin gebelik muayenesinin bir parçası olan 11–13+6 haftada anöploidi taramasına ilave olarak fetal anatomik yapıların farklı CRL değerlerine göre ne oranda görüntülenebileceği saptamaktır.

Yöntem: Retrospektif tanımlayıcı olgu serisi olarak planlanan çalışmada, 1.4.2006–30.09.2017 tarihleri arasında, gebeliğin 11–13+6 haftalarında nukal tarama yapılan toplam 5238 tek fetüse ait veriler analiz edildi. Fetüsler CRL ölçümüne göre 4 gruba (CRL 45–54 mm arası Grup 1, CRL 55–64 mm arası Grup 2, CRL 65–74 mm arası Grup 3, CRL 75–84 mm arası Grup 4) ayrıldı. Her grup için fetüsün organ ve vücut kısımlarının görüntülenebilme oranları hesaplandı ve istatistiksel analizleri yapıldı.

Bulgular: Gebelerin yaş ortalamaları 30.1±4.65 (aralık:17–46), fetüslerin ortanca CRL değeri 62 (aralık: 45–84) mm idi. Tüm gruplarda fetal anatomi görüntüleme başarısı en yüksek olan organ ve bölümler sırasıyla; üst ekstremite, alt ekstremite, kranyum, mide, mesane, ense kalınlığı, burun kemiği, vertebra ve abdomen olarak belirlendi. Bu yapıların hepsinde görüntüleme başarısı %90'ın üzerinde idi. Kalp dört odacık tüm gruplarda %52.6 oranında, kalp büyük damar çıkışları tüm gruplarda %44.3 oranında izlendi. Böbreklerin tüm gruplarda %52.0 oranında gözlenebildiği belirlendi. CRL grupları arasında; kranyum, ense saydamlığı, abdomen duvarı, alt ve üst ekstremite hariç diğer tüm anatomik yapılarda görüntüleme oranları, istatistiksel anlamlı olarak farklıydı. En düşük görüntüleme oranları Grup 1'de iken en yüksek oranlar Grup 4'te idi.

Sonuç: Çalışmamızda 11–13+6 hafta anöploidi taraması sırasında, fetüsün kalp ve böbreklerin dışında kalan temel anatomik yapılarının %90'ın üzerinde başarılı bir şekilde görüntülenebildiğini, görüntüleme oranlarının beklendiği gibi gebelik haftasına paralel olarak arttığı saptandı. Klasik olarak nukal tarama zamanlamasında 11-12 haftalar daha uygun iken fetal anatomi değerlendirmesi için 12-13. haftalar tercih edilebilir.

Anahtar sözcükler: 11–13 hafta, fetal anatomi, ultrasonografi, görüntüleme başarısı, ilk trimester, fetal kalp.

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Introduction

Fetal structural anomalies are seen in 2–3% of all pregnancies.[1] Today, ultrasonography (USG) has become an inseparable part of routine prenatal care for the detection of these structural anomalies in developed countries. Although the mid-trimester anatomic USG evaluation performed between 18 and 22 weeks of gestation has been a standard approach to detect fetal structural anomalies for a few decades, the detection of fetal anomalies has increased and it has become possible to diagnose in the earlier weeks of gestation thanks to the continues improvements in the ultrasound resolution and increased experiences of specialists. First trimester detection of structural anomalies supports the early diagnosis of chromosomapathies as they may be concomitant with chromosomapathies while it also provides an early opportunity to get information and investigate the prognosis of isolated structural anomalies and prenatal or postnatal treatment options. It has become possible to detect fetal anomalies during the early weeks of gestation due to the use of transvaginal (TV) USG[2,3] together with the first trimester USG screening of chromosomal anomalies and increase in the USG resolution in time.

The primary purpose of USG examination in the first trimester was to identify the fetal vitality, to determine fetus number and exact week of gestation. The measurement of nuchal translucency at 11–13^{+6} weeks of gestation included in the prenatal care beginning from the early 1990s[4] paved the way for the assessment of early fetal anatomy. With the detailed examination of fetal anatomy during first trimester, 27.5–62% of all major structural anomalies can be detected.[3,5,6] Sonography at first trimester has become an applicable option and even a routine practice in some institutions. First trimester structural anomaly examination may be more beneficial in populations with high risks such as anomaly history in previous pregnancies particularly for fetal anomalies, high values of nuchal translucency and increased biochemical risk or in populations where second trimester USG is technically difficult as in obese women. Since some fetal structures such as cerebellar vermis or corpus callosum are not completely developed in the first trimester, first trimester examination may detect at least half of the structural anomalies although it cannot rule out abnormalities in these structures. In mid-trimester examination, this rate is reported 60%.[7,8]

We aimed to investigate the imaging rates of fetal anatomic structures according to different CRL values, and therefore to find out which CRL values would be more ideal for the examination of fetal structural anomalies together with chromosomapathy screening in this examination in addition to the aneuploidy screening at 11–13^{+6} weeks which is currently a part of the routing gestational examination.

Methods

In this study which was planned as retrospective descriptive case series, the data of 5,238 single fetuses which had nuchal screening at 11–13^{+6} weeks of gestation between April 1, 2006 and September 30, 2017 were collected retrospectively, and imaging success of various organs and anatomic structures were evaluated retrospectively.

The fetuses were assessed according to the guides of that period (Fetal Medicine Foundation - London - http://www.fetalmedicine.com), and USG examinations were performed transabdominally by two operators using HDI 4000 (Philips Healthcare, Andover, MA, USA) and Voluson 730 Pro, Voluson 730 Expert, Voluson E10 (General Electric Healthcare, Chicago, IL, USA). Transvaginal method was preferred only in cases where NT could not be seen (3%). Fifteen minutes at least and 20 minutes at most was allocated for each pregnant woman. When necessary, color Doppler blood flows were used for the presence and associations of vessels.

Cranial bones, midline falx cerebri, ventricles filled with choroid plexus, intracranial translucency, nuchal translucency, facial orbita, nasal bone, maxilla and mandible, vertebra and skin from cervical area to sacral area, symmetric lung tissues and pleural space in thorax, four-chamber view (the presence of two atriums, two ventricles and septum, space of atrioventricular valves), large vessel crossings, abdominal skin, integrity of anterior wall, stomach, kidneys, umbilical cord, umbilical arteries and bladder, long bones of lower and upper extremities, hands and feet, joint motions, and blood flows of ductus venosus and bilateral uterine artery were seen during fetal anatomic examination. The images were recorded to device memory, their photographs were taken, and they were reported also by recording in the computer system. When related internal structures and other parts could not be seen completely in especially the examinations of face, heart and extremities, no comment was added and the data field for related organ was left empty.

Fetuses were separated into 4 groups according to the CRL measurements (Group 1: CRL between 45 and 54 mm, Group 2: CRL between 55 and 64 mm, Group 3: CRL between 65 and 74 mm, and Group 4: CRL between 75 and 84 mm). For each group, the imaging rates of organ and body parts mentioned above were calculated and statistical analyses were carried out.

SPSS version 16 for Windows (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. For descriptive data, the descriptive statistical methods (mean, standard deviation) were used. Crosstabs were prepared for intergroup rates by descriptive analysis, and the presence or absence of difference among groups was calculated by chi-square test. The significance level was considered $p<0.05$.

Results

The mean age of pregnant women was 30.1±4.65 (range: 17 to 46) years, and median CRL value of fetuses was 62 (range: 45 to 84) mm. Basic recorded data of 5188 pregnant women were accessed, and 50 cases without basic data were excluded from the study. The distribution of pregnant women according to their CRL values is shown in **Table 1**.

In all groups, the organs and parts with the highest success of fetal anatomy imaging were upper extremity, lower extremity, cranium, stomach, bladder, nuchal translucency, nasal bone, vertebra and abdomen, respectively. The imaging rate for all of these structures was above 90%. The imaging rates of fetal anatomy according to CRL groups are shown in **Tables 2** and **3**.

The cranium was observed with a rate of 99.3% in all groups. There was no statistically significant difference among CRL groups in terms of observing the cranium (p=0.056).

It was found that the nuchal translucency could be measured in 97.4% of all groups. There was no statistically significant difference among CRL groups in terms of measuring NT (p=0.169).

The nasal bone was seen with a rate of 95.8% in all groups. There was statistically significant difference among CRL groups in terms of imaging the nasal bone ($p<0.0001$). Group 2 had the highest rate (96.7%) while Group 1 had the lowest rate (92.5%).

The vertebra was seen with a rate of 95.6% in all groups, and there was statistically significant difference among CRL groups in terms of observing the vertebra ($p<0.001$). While the lowest observation rate was 83.6% in Group 1, the highest rate was 99.0% in Group 4.

The visualization of four-chamber was achieved with a rate of 52.6% in all groups, and there was statistically significant difference among CRL groups in terms of observing the four-chamber ($p<0.001$). While the lowest rate for observing four cardiac quadrants was 40.1% in Group 1, the highest rate was 64.4% in Group 4.

Table 1. Numbers and percentages of groups according to CRL measurement.

Group	CRL (mm)	n	%
1	45–54	799	15.4
2	55–64	2373	45.7
3	65–74	1626	31.3
4	75–84	390	7.5
Total		5188	100

Table 2. Imaging rates of fetal structural areas I (%).

CRL (mm)	n	Cranium	Nuchal translucency	Nasal bone	Vertebra	Thorax
45–54	799	98.7	97.0	92.5	86.7	82.1
55–64	2373	99.7	97.9	96.7	97.1	91.2
65–74	1626	99.1	96.8	96.0	96.9	92.6
75–84	390	99.2	97.4	96.2	99.0	96.2
Total	5188	99.3	97.4	95.8	95.6	90.6

Table 3. Imaging rates of fetal structural areas II (%).

CRL (mm)	n	Abdominal wall	Stomach	Kidney	Bladder	Upper extremity	Lower extremity
45–54	799	92.1	97.1	33.5	90.0	100	99.1
55–64	2373	93.1	99.4	48.8	97.1	99.7	99.6
65–74	1626	94.4	99.8	60.4	97.0	99.9	99.4
75–84	390	93.3	99.8	74.4	97.9	98.9	99.7
Total	5188	93.4	99.0	52.0	96.0	99.8	99.5

Cardiac outflow tracts were examined in 4045 fetuses beginning from 2008 and it could be identified with a rate of 44.4% in all groups. There was a statistically significant difference among CRL groups in terms of observing the major cardiac outflow tracts (p<0.001). While the lowest observation rate was 34.3% in Group 1, the highest rate was 60.1% in Group 4. The imaging rates of four-chamber and cadiac outflow tracts are given in **Table 4**.

The thorax and associated structures were seen with a rate of 90.6% in all groups, and there was statistically significant difference among CRL groups in terms of observing the lungs (p<0.001). While the lowest observation rate was 82.1% in Group 1, the highest rate was 96.2% in Group 4.

The abdominal wall was seen with a rate of 93.4% in all groups, and there was no statistically significant difference among CRL groups in terms of observing the abdomen (p<0.315).

The stomach was seen with a rate of 99.0% in all groups, and there was statistically significant difference among CRL groups in terms of observing the stomach (p<0.001). While the lowest observation rate was 97.1% in Group 1, the highest rate was 99.8% in Groups 3 and 4.

The kidneys were seen with a rate of 52.0% in all groups, and there was statistically significant difference among CRL groups in terms of observing the kidneys (p<0.001). While the lowest observation rate was 33.5% in Group 1, the highest rate was 74.4% in Group 4.

The bladder was seen with a rate of 96.5% in all groups, and there was statistically significant difference among CRL groups in terms of observing the bladder (p<0.001). While the lowest observation rate was 90.0% in Group 1, the highest rate was 97.9% in Group 4.

The details of upper extremities were observed with a rate of 99.8% in all groups, and there was no statistically significant difference among CRL groups in terms of observing the upper extremities (p<0.201).

The lower extremities were observed with a rate of 99.5% in all groups, and there was no statistically significant difference among CRL groups in terms of observing the lower extremities (p<0.299). While the lowest observation rate was 99.1% in Group 1, the highest rate was 99.7% in Group 4.

Discussion

Our study has shown that structural examination of fetus during routine nuchal screening program at 11–13^{+6} weeks of gestation can be easily done in structures except four-chamber, outflow tracts and kidneys. General anatomical structures except heart, outflow tracts and kidneys had an imaging rate over 90% in proportion to CRL increase.

In a screening study performed for structural abnormalities by using TV USG, it was possible to image fetal anatomy in 94% of the cases except face and heart.[3] Although we reached these rates in our study in time by the increase in the resolution of ultrasonography devices and operators' experiences and TA USG, we found that certain rates could not be exceeded for imaging heart and kidneys in the examination at 11–13^{+6} weeks of gestation. Successful imaging rates for heart chambers and kidneys were 44.6% and 52.0%, respectively.

In the echocardiography study of Hutchinson et al.,[9] the imaging rate for cardiac outflow tracts during 11–13^{+6} weeks of gestation was 79%. In fact, the authors could identify four-chamber even at 8 weeks of gestation at a rate over 50%. However, Souka et al.[10] could achieve the same rate (79%) for cardiac outflow tracts only during detailed examination at 20–24 weeks of ges-

Table 4. Imaging rates (%) of four-chamber view and cardiac outflow tracts, and the numbers of analyzed fetuses.

CRL	Four-chamber (n)	Imaging rate for four-chamber (%)	Cardiac outflow tracts (n)	Imaging rate for vein outlets of heart (%)
45–54 mm	799	40.1	637	34.1
55–64 mm	2373	51.6	1962	42.8
65–74 mm	1626	57.5	1232	49.4
75–84 mm	390	64.4	214	60.3
Total	5188	52.6	4045	44.4

tation. While Souka et al.[10] reported 87.4% as the imaging rate for four-chamber in the first period and 49.9% as the imaging rate for cardiac outflow tracts, these rates were 52.6% and 44.4% in our study, respectively. In their presentation to detect cardiac anomalies in 519 cases, Dilek et al. from Turkey[11] reported that they documented the images of four-chamber in all cases and the images of cardiac outflow tracts in 75% of the cases. In our study, the rates of observing outflow tracts are lower than the rates reported by Hutchinson et al.[9] and Dilek et al.[11] and close to the rates reported by Souka et al.[10] We believe that this is the result of device quality in the first years, not performing special examination on heart and relatively short evaluation period.

Souka et al.[12] combined TA and TV USG in their study in 2004, and reported the imaging rates at 11–14 weeks screening over 99% in the structures except four-chamber (87.4%) and kidneys (87.6%). Ebrashy et al.[13] compared the imaging rates of fetal anatomy at 13–14 weeks of gestation by TA and TV USG, and they reported that the anatomical structures could be observed at a rate over 90% by TV USG except heart and kidneys. In our study where we evaluated 97% of the fetuses by TA USG, we obtained rates similar to TA USG rates of that study. In the study of Ebrashy et al., imaging rates of the structures except abdominal wall were below 90% by TA USG although the examination was performed at only 13 and 14 weeks of gestation. In our study, the rates we found for the same structures are higher.

The detection rate of fetal structural anomalies at 11–13+6 weeks was reported 27.5% in the study of Hernandi and Töröcsik[3] performed on 3991 cases, 53.8% in the study of Economides et al.[14] performed on 1632 cases, and 22.3% in the study of Carvalho et al.[15] performed on 2853 cases. Weiner et al.[16] performed fetal anatomy screening at 11–14 weeks of gestation only when they suspected of structural anomaly when examining the fetus on sagittal plane, and they highlighted that approximately 50% of fetuses with structural anomalies could be detected in this way. Hildebrand et al.[17] reported fatal anomalies with a rate of 88% at the first trimester and 92% at the second trimester, the anomalies that may have adverse results in future with a rate of 35% at the first trimester and 44% at the second trimester, and all anomalies during routine screening with a rate of 13% at the first trimester and 29% at the second trimester. In Turkey, Dane et al.[18] reported that they could detect major anomalies with a rate of 70% at the first trimester.

In a study performed on 44,859 cases at an early period, the detection rate for structural anomalies was reported 43.6%.[6] All acrania, alobar holoprosencephaly, exomphalos, gastroschisis, megacystis and vertebra anomalies and 77% of hand or foot ageneses, 50% of diaphragmatic hernia cases, 50% of fatal skeletal dysplasia cases, 60% of polydactyly cases, 34% of major cardiac defects, 5% of cleft lips and palates, and 14% of open spina bifida cases could be diagnosed.[6]

Melekoğlu et al.[19] from our country reported that 33.3% of cases with ventriculomegaly, 25% of cases with cleft lip-palate, 43.7% of cardiac malformations, 33.3% of cases with diaphragmatic hernia and 75% of cases with lethal skeletal dysplasia were detected during first trimester screening program, but agenesis of corpus callosum, Dandy-Walker malformation, congenital pulmonary airway malformation and pulmonary sequestration anomalies could not be detected during first trimester screening. In our study, we did not perform detailed analysis and comparison for the anomalies we detected; however, we determined that the imaging rates for organs and structures with anomaly in the literature were consistent with the imaging rates we found in our study.

In a systematic analysis performed on 78,002 cases in Italy, structural anomaly detection rate at 11–13+6 weeks of gestation was 51% by TA USG, 43% by TV USG and 62% by the combination of both techniques, and it was found that cardiac anomaly detection rate increased to 53% if fetal echocardiography is conducted which was 43% in routine screening.[5] In another meta-analysis, 115,731 fetuses with low risk were evaluated, and detection rate for systemic major anomalies at 11–13+6 weeks of gestation was found 46.1% and the rate to detect all anomalies was 32.4%.[20]

As the gestational week increases, the rates to detect structural anomalies also increase; the detection rate which is 45% at 11 weeks of gestation increases to 76% at 14 weeks of gestation.[21] Similarly, imaging success for almost all structures in our study was the lowest in Group 1 and the highest in Group 4 (in those with statistically significant difference). The highest imaging rate for nasal bone was in Group 2; the rates of Groups 3 and 4 were also similar to the rates of Group 2. This is also consistent with the fact that imaging nasal bone is easier after 11 weeks of gestation.[22]

In our study, while successful imaging rate for kidney is 33.5% when CRL is between 45 and 54 mm, it increases with the increase of CRL and reaches to 60.4% when CRL is between 65 and 74 mm, and 74.4% when CRL is between 75 and 84 mm. Souka et al.[12] found median CRL 64.9 mm in their study and reported this rate 77.9 and 87.6% by TA and TV USG at 11–14 weeks of gestation, respectively. Ebrashy et al.[13] included only 13–14 weeks old fetuses in their studies, and reported these rates 63% for TA USG and 85.6% for TV USG. Although the general rate in our study is 52%, our rates during these weeks are 60.4% and 74.4%, respectively. The fetuses in this study being only at 13 and 14 weeks old explain the high imaging success. In a prospective study performed on 2876 cases which also give anomaly incidence, no renal pathology was diagnosed at 13–14 weeks of gestation.[13] Similarly, Hildebrand et al.[17] reported in their study performed on 21,189 cases that they did not diagnose any renal pathology at 11–14 weeks of gestation.

Although approximately one out of two structural anomalies can be detected at first trimester screening, agenesis of corpus callosum, cerebellar or vermis hypoplasia, echogenic lung lesions, intestinal obstruction, renal defect or talipes cannot be diagnosed at first trimester examination.[6] Harper et al.[23] reported in their analysis that fetal anatomy screening at the first trimester may increase the detection of fetal anomalies, but considering the fetal anomaly prevalence below 5% in general and overweight populations, many screenings would be needed to detect a single additional anomaly, and therefore first trimester anatomy screenings can be suitable only for fetal anomalies in populations under high risk.

Conclusion

Thanks to the developing technology and extensive knowledge, imaging basic fetal organs and structures at $11–13^{+6}$ weeks is now possible. The main purpose is to detect major anomalies early in particular. In our study, we found that basic fetal structures except heart and kidneys can be successfully observed with a rate over 90% at early period examinations. High imaging success can be possible by increasing device quality and the time allocated for examination, and also choosing transvaginal examination method.

Conflicts of Interest: No conflicts declared.

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