The Reference Diameters of the Three Great Vessels in the Fetuses Between 20-24 Weeks by Sonography

Sonografide 20-24 Hafta Arasındaki Fetüslerde Üç Büyük Damarın Referans Çapları

Yazışma Adresi
Correspondence Address

Cihat AKSOY
Akdeniz University,
Faculty of Medicine,
Department of Radiology,
Antalya, Turkey
caksoy007@gmail.com

Cihat AKSOY
Akdeniz University,
Faculty of Medicine,
Department of Radiology,
Antalya, Turkey

ORCID ID: 0000-0001-8287-2547

Ayse SIMSEK
Akdeniz University,
Faculty of Medicine,
Department of Pediatric Cardiology,
Antalya, Turkey

ORCID ID: 0000-0001-6387-4926

Ozhan OZGUR
Akdeniz University,
Faculty of Medicine,
Department of Radiology,
Antalya, Turkey

ORCID ID: 0000-0001-9670-4720

Emel DURMAZ
Akdeniz University,
Faculty of Medicine,
Department of Radiology,
Antalya, Turkey

ORCID ID: 0000-0002-1125-9902

Ali APAYDIN
Akdeniz University,
Faculty of Medicine,
Department of Radiology,
Antalya, Turkey

ORCID ID: 0000-0002-0205-311X

H.Timur SINDEL
Akdeniz University,
Faculty of Medicine,
Department of Radiology,
Antalya, Turkey

ORCID ID: 0000-0003-4537-0462

ABSTRACT
Objective:
We aimed to obtain reference values of three major vessels [Pulmonary artery (PA), aorta, superior vena cava (SVC)] diameters in fetuses between 20-24 weeks of gestation in the Turkish population and to evaluate the fetal heart anatomy.

Material and Methods:
Pregnant women who were evaluated in the Radiology Department were scanned by sonography in order to obtain fetal cardiac nomograms of the great vessels. Cardiac axis, size and three great vessels in addition to the four chamber view of the heart were evaluated. The cases were followed up postnatally with echocardiography and clinical evaluation. We calculated both the sensitivity and specificity of sonographic screening at the 20-24th gestational weeks. Also, we found the frequency of congenital cardiac disease. Nomograms were obtained by calculating average vascular diameter for each gestational week.

Results:
A total of 371 fetuses were evaluated in the sudy. The mean gestational age was 29.2±5.2. The mean diameters of PA, aorta and SVC were found as 4.28±0.51 mm, 3.70±0.54 mm, 2.45±0.45 mm, res- pectively. The ratio of PA/aorta was 1.17±0.14. The mean diameters of PA, aorta and SVC increased gradually between 20 and 24 gestational weeks (p values 0.001, 0.007 and 0.001; repeated measures ANOVA). In five cases a cardiac anomaly was detected (tetralogy of Fallot, one atrium one ventricle anomaly, ASD, PA wider than normal, aorta wider than normal,) sonographically. Of these five, three cases were confirmed by postnatal fetal echocardiography performed by pediatric cardiologists.

Conclusions:

This study represents the reference values for diameters of three great vessels of fetuses between 20 and 24 weeks in the Turkish population. The data obtained from our study will be a reference for future studies from our country.

Key Words:

Congenital heart disease, Ultrasonography, Prenatal screening

ÖZ

Amaç:

Fetal kalp anatomisini değerlendirmek ve Türk popülasyonunda 20-24 hafta arasındaki fetüslerde üç ana damar [Pulmoner arter (PA), aorta, vena kava süperior (VKS)] çaplarının referans değerlerini saptamayı amaçladık.

Gereç ve Yöntemler:

Radyoloji Bölümünde değerlendirilen gebelere fetal kardiyak büyük damarların nomogramlarının elde edilmesi için sonografik tarama yapıldı. Kalbin dört odacık görünümüne ek olarak kardiyak aks, boyut ve üç büyük damar değerlendirildi. Olgular postnatal olarak ekokardiyografi ve klinik değerlendirme ile takip edildi. Postnatal değerlendirme sonuçları temel alınarak 20-24. gebelik haftalarında yapılan sonografik taramanın duyarlılığı ve özgüllüğü hesaplandı. Ayrıca konjenital kalp hastalığı sıklığı araştırıldı. Her gebelik haftası için ortalama damar çapı hesaplanarak nomogramlar elde edildi.

Bulgular:

Çalışma kapsamında toplam 371 fetüs değerlendirildi. Ortalama gebelik yaşı 29,2±5,2 yıldı. PA, aorta ve VKS ortalama çapları sırasıyla 4,28±0,51 mm, 3,70±0,54 mm ve 2,45±0,45 mm olarak bulundu. PA/aort oranı 1,17±0,14 idi. PA, aort ve VKS'nin ortalama çaplarının 20 ila 24 gebelik haftaları arasında kademeli olarak arttığı gözlendi (p değerleri 0,001, 0,007 ve 0,001). Sonografik olarak antenatal dönemde beş olguda kardiyak anomali (Fallot tetralojisi, tek atriyum tek ventrikül anomalisi, ASD, normalden geniş PA, normalden geniş aorta) tespit edildi. Beş vakadan üçünün tanısı doğum sonrası dönemde pediatrik kardiyologlar tarafından yapılan fetal ekokardiyografi ile doğrulandı.

Sonuç:

Bu çalışma, 20-24 gestasyon haftasındaki fetüslerde üç büyük damar çapı için Türk popülasyonuna ait referans değerleri sunmaktadır. Çalışmamızdan elde edilen veriler ülkemizden yapılacak çalışmalar için referans oluşturacaktır.

Anahtar Sözcükler:

Konjenital kalp hastalığı, Ultrasonografi, Prenatal tarama

INTRODUCTION

Second trimester sonographic examination is very important in preventing neonatal morbidity and mortality due to congenital cardiac anomalies (1). Congenital heart disease (CHD) is the most common congenital anomaly, the incidence of CHD range from 4 / 1,000 to 50 / 1,000 live births in different studies (2). One fourth of newborns with congenital heart disease have an increased morbidity and mortality rate (3). Detection of congenital cardiac anomalies in the fetal period will provide a chance for treatment and intervention for these patients (4). Current screening technique includes four-chamber, right ventricular outflow tract, and left ventricular outflow tract views. The three-vessel view is also often used in screening. These views are essential for a complete evaluation of the fetal heart (5,6). Previous studies claimed that four-chamber view was sufficient for detecting fetal congenital structural abnormalities (6-9). Using four-chamber view, the rate of CHD diagnosis was about 60%, which was less than expected (7-10). In some CHD, such as Tetralogy of Fallot and transposition of the great vessels, it cannot be detected by the four-chamber view (9,10).

Wong et al., explained that 86% CHD can be detected using the three-vessel viewing plane of the main vessels [pulmonary artery (PA), aorta, superior vena cava (SVC)] and the PA/aorta ratio (11). In the second trimester fetal cardiac screening, it is recommended to add the measurement of anatomical structures in addition to subjective assessments in cardiac examination. The nomograms of the diameters of three vessels in the second trimeste are very important because abnormal measurements are a clue in the diagnosis of heart diseases. In our unit, we perform fetal cardiac examinations between 20 and 24 weeks of gestation. Thus, we aimed to conduct a prospective study to reveal the nomograms of the three great vessels corresponding to each week in the fetuses between 20-24 gestational weeks by sonography.

MATERIAL and METHODS

Study design

Four hundred thirty-nine pregnant women who applied to our Radiology department for routine fetal organ screening were included in the study. Among these patients, those who were followed up during the fetal and postpartum periods and those who stated in written form they participated in the study were included in the study. Exclusion criteria were as follows: etuses with cardiac anomaly, fetuses with chromosomal anomaly, fetuses with extra cardiac anomaly, fetuses whose mothers had cardiac disease history, fetuses whose brothers had fetal cardiac anomaly history and multi-parity. Also, pregnant women who had an inconsistency between the gestational age calculated according to the last menstrual period and the gestational age obtained according to ultrasound measurements were excluded from the study. Approval was obtained from the Clinical Research Ethics Committee of Akdeniz University Faculty of Medicine (Decision Number: 01/22, date:08.01.2013). The study was conducted in accordance with the Helsinki Declaration. All pregnant women included in the study were informed and signed voluntary consent forms were obtained.

After excluding 33 pregnant women without regular follow-up, were included in the study. In five cases a cardiac anomaly was detected (tetralogy of Fallot, one atrium one ventricle anomaly, ASD, PA wider than normal, aorta wider than normal,) sonographically. Of these five, three cases were confirmed by postnatal fetal echocardiography performed by pediatric cardiologists. These 5 patients with cardiac anomaly were excluded from the study.

The study was continued with 371 pregnant women. The pregnant women were evaluated in 20-24 weeks of gestation according to their menstruation age. All patients were re-evaluated with clinic and echocardiographic indings in the postnatal period.

Imaging method

Ultrasonography (US) images were obtained in three-vessel view. Technically we found first four-chamber view in transaxial plane which is perpendicular to the long axis of the fetus. From four-chamber view, we moved slightly the transducer on the patient without changing angle toward the fetal head. When we saw three-vessels in line with each other in the order of largest PA to smallest SVC, we froze the image to take measurements of vessel diameter parallel to the anterior thoracic wall or perpendicular to the fetal ribs. In addition, PA/aorta ratio was calculated (Figure 1).
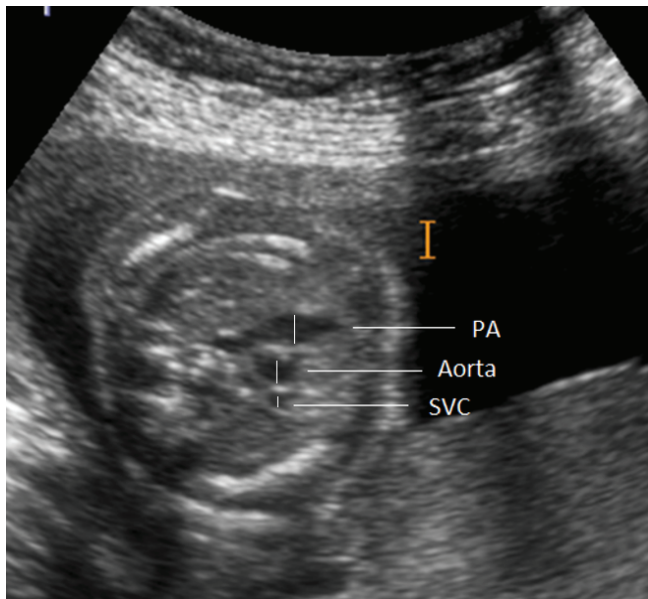
Figure 1: Pulmonary artery (P) and aorta (A) and SVC measurement, showing the appearance of three-vessels view in the transverse plane of the fetal thorax.

One of the radiologists had ten years of experience for fetal imaging. The other radiologist had 5 years of experience for general radiology. The US reports and images of all patients were enrolled for follow-up by the same radiologists to our digital US archive (Tomtec Imaging Systems, version 2.7, Munich, Germany).

Statistical Evaluation

Linear regression analyses was used to generate nomograms. Descriptive statistics were presented as frequency, percentage, mean, standard deviation (SD) and 95% CI. The Shapiro Wilk test, histogram and Q-Q graphics were used for evaluation of normality of distribution. The Fisher's Exact Test was used in the analysis of relationships between categorical variables. Diameters of PA, aorta, SVC and PA/aorta ratio were compared between gestational weeks using repeated measures ANOVA. Comparison between two different groups was performed through two independent samples T-Test and comparison between more than two groups was performed with Kruskal-Wallis analysis. The statistical analyses were performed by using the SPSS version 21.0 package program for Windows (IBM, Armonk, NY). $p < 0.05$ were accepted significant to show statistical significance.

RESULTS

A total of 371 pregnant women with mean age of 29.2 ± 5.2 years were included in the study. In 371 fetuses between 20-24 weeks, the mean diameters of PA, aorta and SVC were found as 4.28 ± 0.51 mm (95% CI: 4.23-4.34; range 2.6–5.6); 3.70 ± 0.54 mm (95% CI: 3.64-3.76; range 2.0-5.2); 2.45 ± 0.45 mm (95% CI: 2.41-2.50; range 1.6-3.8) respectively (Table I).

Table I: The mean diameters of PA, aorta and SVC and PA/aorta ratio in the fetuses between 20-24 gestational weeks (n: 371).

| Variable	Min.	Max.	Mean and SD	95% CI
PA	2.60	5.60	4.28 (±0.51)	4.23-4.34
Aorta	2.00	5.20	3.70 (±0.54)	3.64-3.76
SVC	1.60	3.80	2.45 (±0.45)	2.41-2.50
PA / aorta	0.98	1.95	1.17 (±0.14)	1.15 – 1.18

PA: Pulmonary artery SVC: Superior vena cava. The ratio of PA/aorta was 1.17 ± 0.14 (95% CI: 1.15 – 1.18; range 0.98-1.95). In each screening week between 20 and 24, you can find the diameters of PA, aorta, SVC and PA/aorta ratio in Figure 2-5 and Table II.
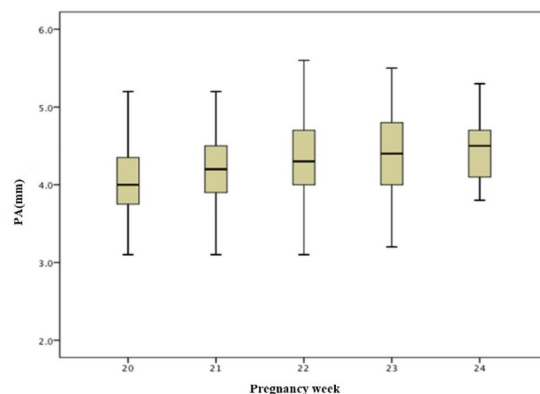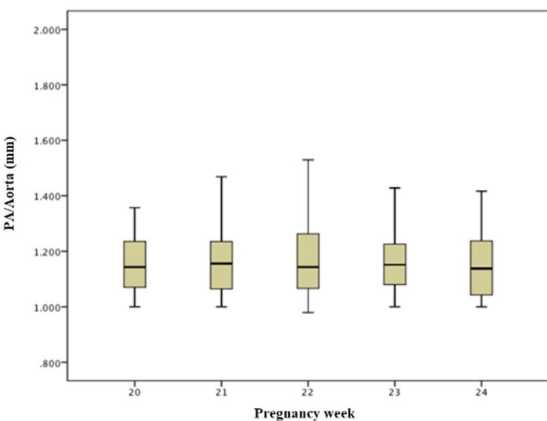

Figure 2: The values of PA according to gestational age in normal 371 cases (p: 0.001).
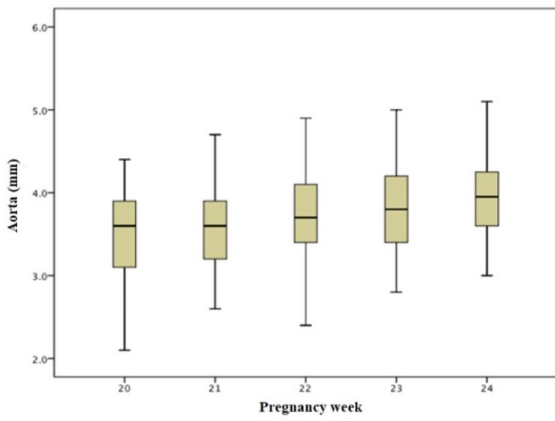
Figure 3: The values of aorta according to gestational age in 371 normal cases (p: 0.007).
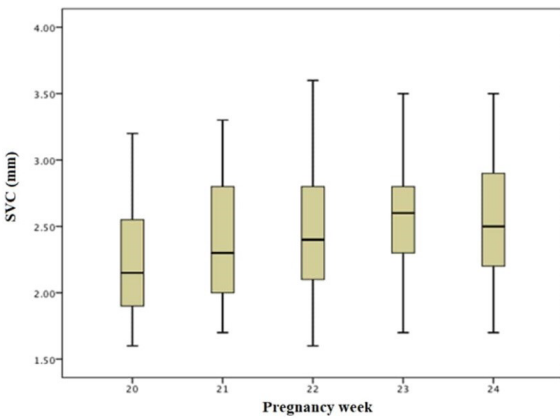
Figure 4: The values of SVC according to gestational age in 371 normal cases (p: 0.001).

Figure 5: The values of Pa/aorta according to gestational age in normal 371 cases (p: 0.961).

Table II. The mean diameters of PA, aorta and SVC, and PA/aorta ratio of 371 fetuses with regular follow-up according to gestational age.

—	Gestational age (weeks)	n (371)	Min.	Max.	Mean and SD	95% CI	P
PA	20	40	2.6	5.2.	4.00 ±0.53	3.83-4.17	0.001
	21	65	2.7	5.2	4.19 ±0.50	4.07-4.32	
	22	143	2.6	5.6	4.30 ±0.50	4.22-4.39	
	23	79	3.2	5.5	4.38 ±0.49	4.27-4.49	
	24	44	2.7	5.3	4.44 ±0.47	4.29-4.58	
Aorta	20	40	2.1	4.4	3.48 ±0.54	3.31-3.66	0.007
	21	65	2.6	4.7	3.61 ±0.53	3.48-3.74	
	22	143	2.0	5.2	3.70 ±0.53	3.61-3.79	
	23	79	2.8	5.0	3.79 ±0.53	3.67-3.91	
	24	44	2.6	5.1	3.88 ±0.54	3.71-4.04	
SVC	20	40	1.6	3.2	2.26 ±0.42	2.12-2.40	0.001
	21	65	1.7	3.3	2.37 ±0.41	2.27-2.47	
	22	143	1.6	3.6	2.45 ±0.45	2.37-2.52	
	23	79	1.7	3.6	2.57 ±0.44	2.49-2.68	
	24	44	1.7	3.5	2.54 ±0.47	2.39-2.68	
PA/ aorta	20	40	1.16	1.53	1.16 ±0.12	1.12-1.19	0.961
	21	65	1.00	1.65	1.17 ±0.13	1.14-1.20	
	22	143	0.98	1.95	1.17 ±0.15	1.15-1.20	
	23	79	1.00	1.50	1.16 ±0.11	1.14-1.19	
	24	45	1.00	1.58	1.15 ±0.13	1.11-1.19	

The mean diameters of PA, aorta and SVC were increasing gradually between 20 and 24 gestational weeks (p values 0.001, 0.007 and 0.001; repeated measures ANOVA). But PA/aorta ratio was stable between 20-24 gestational weeks (p: 0.961, repeated measures ANOVA).

The great vessel diameters in fetuses of mothers older than 35 years were similar to those of mothers younger than 35 years (p: 0.559 for PA, p: 0.940 for aorta, p: 0.695 for SVC, samples T-Test).

DISCUSSION

During second trimester, screening US should include a comprehensive examination of fetal organs. When it comes to fetal heart, radiologists are not so eager to perform detailed screening. Because in many centers, radiologists think cardiac evaluation is not so easy and requires a special experience.

Because in many center, radiologists think cardiac evaluation is not so easy and requires a special experience: cardiac axis, size, rhythm, four chamber view and finally three vessel evaluation by size. Of course subjective evaluation under experience is a part of cardiac examination of fetal screening. Adding three vessel view evaluation to screening will help to detect more CHD prenatally. In the study of Bromley et al, the frequency of CHD obtained using the four-chamber view was 63%, while the three-vessel view was added to the examination and the frequency increased to 83% (11).

In our study, we evaluated the nomograms of three-vessel diameters between 20-24 weeks of gestation. The mean diameters of PA, aorta and SVC was 4.28±0.51mm, 3.70±0.54mm and 2.45±0.45 mm, respectively. Kenny et al., revealed the nomograms of PA and aorta diameters at 19-40 weeks of gestation, and PA diameter was 12% larger than aorta diameter (12). Cartier et al., obtained nomograms of PA and aorta diameters at 16-40 weeks of gestation according to gestational week and biparietal diameter (13). Also, Achiron et al., obtained nomograms of PA and aorta diameters at 16-24 weeks of gestation according to gestational week (14).

We evaluated PA, aorta and SVC separately according to gestational weeks and it was found that the diameter of all three vessels increased as the gestational week increases. In 2004, Zalel et al., evaluated three vessel diameters at 14-38 weeks of gestation and formulated weekly increases for easy applicability after determining normal values separately for weeks; PA diameter (mm) = −2.275+0.273×gestation week, Aorta diameter (mm) = −1.77+0.227×gestation week and SVC diameter (mm) = −0.98 +0.142×gestation week (15).

In our study, we also calculated the PA/aorta ratio, and we noticed that this ratio did not change between 20 and 24 weeks. The ratio of PA/aorta was 1.17±0.14 (95% CI: 1.15–1.18; range 0.98-1.95). Similarly, Wong et al., found the PA/aorta ratio as 1.16±0.18, and stated that this rate was stable at 16-24 weeks of gestation (11). Determining the normal reference values for three vessel diameters will set a reference for other studies to be conducted in our country. In our point of view, the most useful value that can be helpful in cardiac sonography, is the stable PA/aorta ratio during second trimester. Because the nomograms of great vessel diameters may result in different values in different nations.

We included only 20 to 24 weeks pregnant women in our study in order to see better cardiac anatomical structures. However cardiac screening is most appropriately performed between 18 and 22 weeks (16). It should be kept in mind that especially valvular anomalies can be detected in the following gestational weeks (17). Therefore, in Japan, in addition to the second trimerster evaluation, a cardiac examination is repeated at the 30th gestational week (17).

This study has some limitations. Since the number of the study population was limited and our cases were not randomized, our results didn't reflect whole national population.

CONCLUSION

Our results will be a reference in the fetuses between 20 and 24 weeks during cardiac sonography. Also we found that the ratio PA/aorta was stable between 20-24 gestational weeks with the value of 1.17. We think that this ratio can be used as a reference value, if the radiologist finds very questionable diameters in PA or aorta.

Ethics Committee Approval:
Ethics commitee approval was received from the Ethics Committee of Akdeniz University Medical Faculty for this study (Decision Number: 01/22, date:08.01.2013). The study was conducted in accordance with the Helsinki Declaration.

Informed Consent:
All the participants' rights were protected and written informed consents were obtained before the procedures according to the Helsinki Declaration.

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