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Original Article

Nomogram of Fetal Pulmonary Artery Diameter in Second Trimester of Pregnancy

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Abstract

Objective: The purpose of the present study was to construct a nomogram for fetal pulmonary artery diameter (PAD) in three-vessel view plane in the second trimester of pregnancy.

Material and Methods: The study was carried out on women who were sent for their routine obstetric ultrasound between the gestational age (GA) of 18-26 weeks. After obtaining written and informed consent 451 subjects were included in the study according to predefined criteria. Fetal PAD was measured in three-vessel view plane which was obtained by cephalad movement of transducer from four chamber view.

Results: Mean age of study subjects was 24 years. GA of study participants ranged from 18 to 26 weeks with the mean GA of 21 weeks. The PADs ranged from 2.46 mm at 18 weeks of gestation to 4.61 mm at 26 weeks of gestation with the mean diameter of 3.33 mm. The regression analysis for fetal pulmonary artery was calculated according to GA as PAD = 3.22 + 0.015 × GA. Based on the regression analysis, nomogram for pulmonary artery was established and compared with the previously established nomograms.

Conclusion: A nomogram of fetal PAD was established between the GA of 18-26 weeks and a linear relationship was found between PAD and GA of fetus.

Key words: Fetal pulmonary artery diameter, Second trimester, Three-vessel view

INTRODUCTION

Congenital heart disease (CHD) is one of the most common forms of severe congenital abnormality with the estimated incidence of 8-10 per 1000 live births.[1,2] It is a leading cause of infant mortality, with an estimated incidence of about 4-13 per 1000 live births.[3] In spite of high incidence, cardiac anomalies are not easily diagnosed by routine antenatal ultrasound examination.[4] Currently, four chamber view has been incorporated into the routine prenatal ultrasound examination to detect major heart defects in utero. However, up to 20% of major heart defects, including those of ventricular outflow tracts and great arteries can be missed by using the classical four-chamber view alone.[5] Measurement of fetal pulmonary artery as visualized in three-vessel view can aid in the detection of CHDs such as tetralogy of Fallot, transposition of great vessels, truncus arteriosus, pulmonary atresia, and ventricular outflow abnormalities.[6-8] Hence with the aim to establish a nomogram for fetal pulmonary artery diameter (PAD) in the second trimester between the gestational age (GA) of 18-26-week present study was conducted.

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MATERIALS AND METHODS

Ethics Statement

All patients enrolled in the study were briefed about the nature, and the course of the study and informed consent in the regional language was taken from them after approval from the Institutional Ethics Committee.

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Study Design
This was hospital-based, prospective, cross-sectional, observational, diagnostic study.

Study Setting and Period
This study was carried out in ultrasound section of Department of Radio-Diagnosis from November 1, 2014, to October 30, 2016.

Sample Size
During the study, we recruited 546 cases but with exclusion criteria, 458 subjects (outpatients and in patients) of 18-26 weeks of gestation were included in the study.

Subjects
A study subjects were pregnant women who were referred to ultrasound section of the Department of Radio-Diagnosis for their routine ultrasound scan at 18-26 weeks of gestation who were willing to participate in study and were having singleton pregnancy were included in the study. The women who were not willing to participate in study, having multiple gestation, intrauterine demise were excluded from the study.

In case of more than one examination of a fetus, results of the first examination were excluded from the study.

Equipment Used
Ultrasonography machines available in the department (Voluson S6 WIPRO GE Healthcare Sonography Machine, Philips HD 11XE and Philips Affinity 70 Sonography Machine) with curvilinear 2-5 MHz curvilinear transducer.

Study Methodology
After taking valid consent, cases were enrolled for the study. All obstetric ultrasounds were done strictly following the guidelines under the Pre Conception Pre Natal Diagnostic Technique Act. A predesigned, validated, and pre-tested pro forma was used as a study tool to collect information such as name, age, area of residence, and maternal history for any risk factors of CHD. Then after obstetric ultrasound, fetal echocardiography was done, and PADs were measured in 3 vessel view plane.

Technique[7,9]
The first step in fetal echocardiography is an evaluation of fetal visceral situs (Figure 1). Then, four-chamber view was obtained. Three-vessel view was obtained by sliding the transducer cranially from four chamber view while maintaining the transverse orientation of chest. Three-vessel view demonstrates the main pulmonary trunk in an oblique section and ascending aorta and superior vena cava in transverse section (Figure 2a).

All measurements of pulmonary artery were measured at the level of semilunar valve with pulmonary artery in a longitudinal section. The calipers were placed on the lines that defined the wall, with the crossbar of caliper merging with the border of vessel (Figure 2b). During the scan, two independent measurements were taken, and the average of two was used.

For the purpose of the study, the weeks of GA were rounded downward when days exceeded weeks by <4 days and rounded upward when days exceeded weeks by ≥4 days.

Post Natal Follow-up
Postnatal follow-up of all the study subjects was done. All neonates were evaluated by neonatologist at birth and the first week of life. Only the neonates having a normal cardiac evaluation at birth and first week were included in the study.

Statistical Analysis
The statistical analysis was done using descriptive and inferential statistics using Student's *t*-test, Pearson's correlation coefficient, reliability analysis, and regression analysis. Software used in the analysis was Statistical Product and Service Solutions 17.0 version and EPI_INFO 7.0 and $P < 0.05$ is considered statistical significance.

RESULTS

A total number of 546 study subjects were enrolled in the study. Initially, 50 subjects were evaluated by two observers to look for interclass correlation which was found to be high (98-99%). These cases were not included in the study. In 38 subjects, the measurements of fetal pulmonary artery and aorta were taken twice, but only the last measurements were used in the study. Moreover, 7 subjects were having cardiac anomalies so were excluded from the study. Hence, a total of 451 subjects were included in the study as per the inclusion criteria.

Mean age of the study subjects was 24.22 ± 3.49 years. The majority of our study subjects (87.7%) belonged to rural area. Out of total 451 study subjects, 7.3 % were in 18th week of gestation, 13.7% in 19th week, 16.4% in 20th week, 15.5% in 21st week, 13.6% in 22nd week, 11.8% in 23rd week, 7.1% in 24th week, and 7.3% in 25th and 26th week of gestation (Table 1).

A regression equation was derived from the present study for predicting the fetal PAD if GA was known and it was (Graph 1):

$$PAD = 3.22 + 0.015 \times GA$$

Positive correlation was found between GA and PAD ($r = 0.011$).

Based on the regression equation, a new nomogram was established showing the predicted values of fetal PAD from 18 to 26 weeks of gestation (Table 2).

DISCUSSION

Efforts should be made to increase the detection rates of CHD as there are evidence that neonatal mortality and morbidity improves significantly in prenatally diagnosed cases of CHD. Cartier *et al.* established that measurements of fetal pulmonary artery and aorta can aid in the detection of CHD, so they constructed nomogram for fetal pulmonary artery and aorta for GAs between 14 and 42 weeks. Abnormal size of these vessels contributed the diagnosis of tetralogy of Fallot, aortic atresia, pulmonary atresia, and Marfan syndrome.[7]

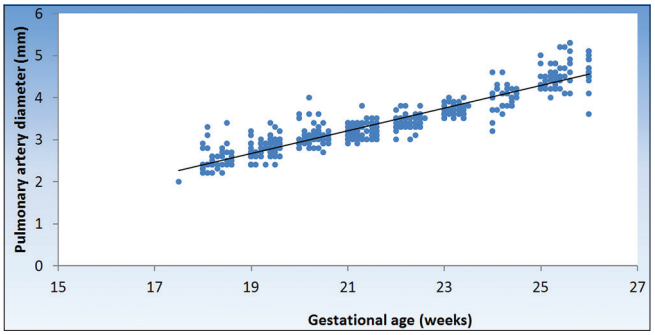
In the present study, 451 fetuses were evaluated between the GA of 18-26 weeks. Cartier *et al.*[7] evaluated the diameter of pulmonary artery in 403 fetuses between the GA of 14 and 42 weeks. Achiron *et al.*[5] evaluated 139 fetus with GA 18-26 weeks and constructed nomogram of pulmonary artery. Wong *et al.*[6] evaluated 966 singleton fetuses for establishing nomogram of fetal pulmonary artery to aortic diameter ratio. Ruano *et al.*[10] constructed nomogram of main pulmonary artery, right and left pulmonary artery in 220 fetuses between the GA of 19 and 40 weeks.

Comparison between the 50th percentile of pulmonary artery diameter of present study and other established studies by Archiron *et al.*[10] Wong *et al.*[11] and Ruano *et al.*[12] was done. Apart from few differences, the 50th percentile

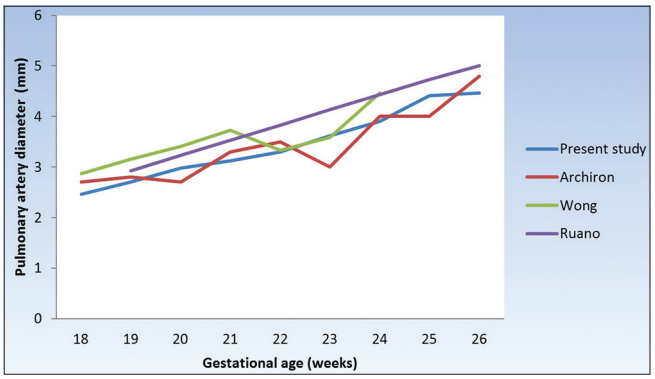
Table 1: Mean PAD of study subjects according to GA

Gestational age (weeks)	Number of study subjects	Mean PAD (mm)
18	33	2.46±0.28
19	62	2.70±0.24
20	74	2.98±0.23
21	70	3.12±0.15
22	61	3.30±0.19
23	53	3.62±0.17
24	32	3.90±0.29
25	33	4.41±0.26
26	33	4.61±0.34
Total	451	3.33±0.65
F value		376.81
P value		0.0001, Significant

GA: Gestational age, PAD: Pulmonary artery diameter



Graph 1: Regression analysis for fetal pulmonary artery diameter according to gestational age



Graph 2: Comparison of 50th percentile of pulmonary artery diameter of normal subjects between present study and others

Table 2: Predicted values for PAD (mm) between 18 to 26 weeks gestation and 95% confidence interval

GA (weeks)	*N*	Mean PAD (mm)	Standard deviation	Standard error	95% confidence interval for mean	
					Lower bound (mm)	Upper bound (mm)
18	33	2.48	0.27	0.04	2.39	2.58
19	62	2.74	0.23	0.02	2.68	2.80
20	74	3.02	0.24	0.02	2.96	3.07
21	70	3.15	0.18	0.02	3.10	3.19
22	61	3.32	0.19	0.02	3.27	3.37
23	53	3.66	0.16	0.02	3.61	3.71
24	32	3.97	0.29	0.05	3.87	4.08
25	33	4.44	0.28	0.04	4.34	4.54
26	33	4.68	0.37	0.06	4.55	4.81
Total	451	3.37	0.66	0.03	3.31	3.43

PAD: Pulmonary artery diameter, GA: Gestational age

of pulmonary artery diameter in our study correlated with pulmonary artery diameters established by Archiron *et al*, Wong *et al* and Ruano *et al*. This difference between the present study and in the other studies may be due to different sample size, different study technique, and different study population. Ours being rural the Indian population having low constitutional weight and height, the measured parameters were less as compared to the Western population.

The regression equation for PAD according to GA was calculated as (Graph 2):

PAD (mm) = 3.22 + 0.015 × GA

This derived regression equation was used to construct nomogram for fetal PAD in the present study.

Different studies have used different regression equations to predict the GA if diameter of pulmonary artery is known.

Cartier *et al*.[7] used the following regression equation for PAD against GA:

PAD (mm) = 0.320 GA−3.0

Where PAD is pulmonary artery diameter.

Achiron *et al*.[5] in their study found that there is strong correlation between the fetal PAD and GA ($r^2 = 0.94\%$) and used following regression equation for PAD as a function of GA was expressed as:

PAD (mm) = −14.7637 + 2.4026 × GA (weeks)

Where PAD is pulmonary artery diameter.

He found that there is high statistical significance between the fetal PAD and GA with *P* value being <0.0001.

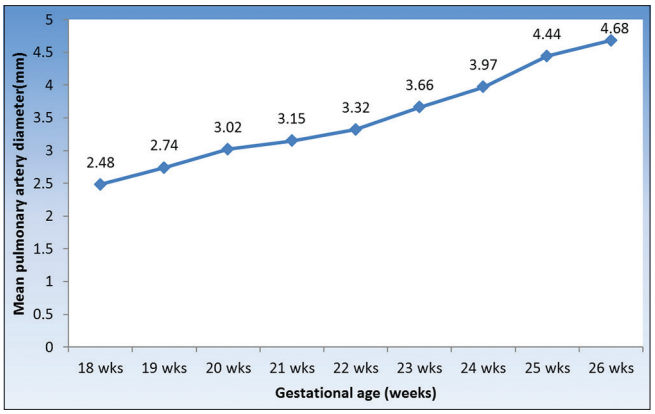
Moon *et al*.[11] in their study concluded that size of pulmonary artery had a significant relationship with GA. Regression equation used for PAD versus GA was (Graph 3):

MPA (mm) = −2.76 + 0.34 × GA

Where MPA is main pulmonary artery diameter.

On the basis of regression equation derived, a new institute specific nomogram was established for prediction of GA by fetal PAD.

The nomogram shows that with increasing GA, there is a progressive increase in the PAD. Fetal PAD in millimeter



Graph 3: Nomogram of pulmonary artery diameter (mm) from 18 to 26 weeks gestation

Figure 1: Transverse view of fetal abdomen with breech presentation and spine at 3 O'clock position identifying the left side of fetus downward. Stomach is seen in cross section of abdomen lying on left side of fetus in the usual position

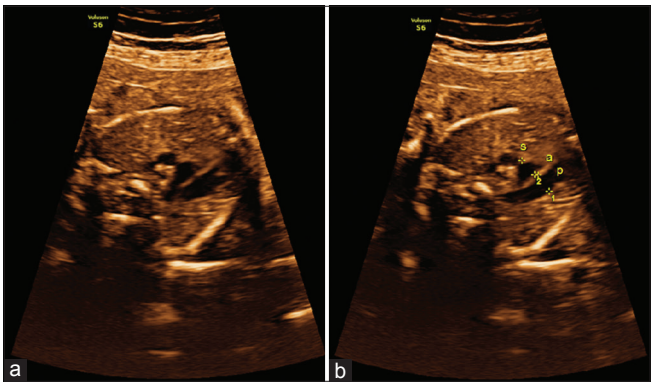


Figure 2: (a and b) Transverse sonographic images of fetus at the level of 3 vessel view demonstrating superior vena cava (anterior), aorta (middle), and pulmonary artery (posterior). Image (b) demonstrating the measurement of fetal pulmonary artery and aortic diameters

with 95% confidential interval ranged from 2.48 ± 0.27 mm at 18 weeks to 4.68 ± 0.37 mm at 26 weeks of gestation with the mean diameter being 3.37 ± 0.66 mm. The diameters

of fetal pulmonary artery by Achiron *et al.*[5] ranged from 2.83 mm at 18 weeks to 4.90 mm at 26 weeks. In the study by Wong *et al.*,[6] fetal pulmonary artery measured between 2.1 and 4.93 mm (mean = 3.3 mm) at 16-24 weeks of gestation. In the study done by Ruano *et al.*,[10] fetal PAD ranged from 2.93 to 5.03 mm at 19 and 26 weeks of gestation. Hence, the nomogram of fetal PAD of the present study was comparable with that of Achiron *et al.* and Wong *et al.*

CONCLUSION

There were significant correlation and linear relationship between fetal PAD and GA of fetus. The nomogram constructed for fetal PAD in 3 vessels view plane can be to screen prenatal cardiac anomalies.

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