DOI: https://doi.org/10.53350/pjmhs221610482

ORIGINAL ARTICLE

Establishing Normal Range of Fetal Pulmonary Artery and Fetal Aortic Diameter in 18-26 Weeks of Gestation in Pakistani Population

BEENISH NADEEM[1], NAUSHABA MALIK[2], MANAL NIAZI[3], SAIRA AHMAD[4], MARIAM HASSAN BUKHARI[5], ARSALAN KHALID[6]
[1,2]Consultant Radiologist, Punjab Employees Social Security Hospital, Islamabad
[3]Professor of Radiology, Akbar Niazi Teaching hospital Islamabad
[4]Radiologist, Punjab Employees Social Security Hospital, Islamabad
[5,6]Resident Radiology, Punjab Employees Social Security Hospital, Islamabad
Corresponding author: Beenish Nadeem, Email: beenishnadeem15@yahoo.com

ABSTRACT

Congenital heart diseases constitute almost 0.8 to 1.2% of newborn illnesses globally however unfortunately 64% of them remained undiagnosed on conventional anamoly scan which uses four chamber view for cardiac evaluation. In developed countries, other than routine anomaly scan, the three vessel view(3VV) has been added to look for any potential outflow tract anomalies which increased the sensitivity of screening CHD however this view is not routinely used in our clinical practice due to lack of expertise and less awareness regarding the importance of this view . We aimed to establish normal reference values of fetal pulmonary and fetal aorta diameter value using 3VV so that its routine use can increase diagnostic accuracy of anamoly scan in our population.

Methodology: This is a non probability convenient study investigating healthy pregnant females between 18-26weeks of gestation conducted from 04-02-2022 to 04-08-2022. After formal ethical approval, 56 patients were included in the study. After achieving 3VV,fetal pulmonary artery and fetal aorta diameter were evaluated and mean values were calculated for each gestational week.

Results: The mean age of pregnant females included is 27.3 + 4.4 years (range 20 -37 years). The pulmonary artery diameter ranged from 2.3mm at 18 week of gestation to 3.6mm at 26 week of gestation. Fetal PAD is observed to correlate linearly (r=0.887) with gestational age and linear regression equation derived as PAD= (-0.52) +0.15(GA). Mean fetal aortic diameter was calculated ranged from 1.5mm at 18 week of gestation to 1.6mm at 26week of gestation. Fetal aorta diameter correlation with gestational was found to be 0.164 showing weak correlation along with insignificant regression analysis hence the regression equation cannot be formulated for fetal aorta.

Conclusion: Normal mean values of fetal pulmonary artery and fetal aorta from 18-26weeks of gestation were calculated. Linear relationship was found between pulmonary artery diameter and gestational age. However weak correlation noted between fetal aorta diameter and gestational age was noted.

Keywords: Fetal pulmonary artery; fetal aorta; anamoly scan; three vessel view(3VV); normal range.

INTRODUCTION

Congenital heart disease contributes almost 0.8-1.2% of newborn diseases globally and includes any anatomical defect in heart or any major vessel that is diagnosed postnatally[1]. Prenatal diagnosis of Congenital Heart Diseases is exceptionally necessary as it warrants for urgent surgical or medical assistance immediately after birth[2]. Routinely used four chamber view in prenatal screening ultrasound can only detect 64% of heart anomalies while the rest gets undetected[4]. Unfortunately, there could be multiple reasons for missing congenital heart anomalies during routine anomaly scan like lack of technical expertise, fetal position or lack of proper magnification of all cardiac planes [4]. In developed countries other than routine anomaly scan, the three vessel view has been added to look for any potential outflow tract anomalies which increased the sensitivity of screening CHD from 30% to 83% at maximum[5]. Hence keeping in view the importance of three vessel view in diagnosing early CHD, our goal is to establish standard reference values of diameter of fetal pulmonary artery and fetal aorta in our population which will be the first study in our reference population. This will improve the screening sensitivity of diagnosing congenital heart diseases antenatally and will also encourage other local researchers to study in this domain.

METHODOLOGY

We conducted this prospective non-probability convenience study in the Radiology Department of Punjab Employee Social Security Hospital Islamabad from 04-02-2022 to 04-08-2022. Objective of the study was to establish mean reference values of fetal pulmonary artery and fetal aorta diameter in three vessel view normal singleton pregnancies ranging from 18-26 weeks of gestation. After approval from hospital ethical committee,56 pregnant women between 18-26 weeks of gestation were selected for the study. These women came for routine ultrasound checkup or anomaly scan. All of these women gave written informed consent. Only women with singleton pregnancies were included in the study and those with comorbidities or any prenatal complications were excluded. The patients were evaluated by senior radiologist and ultrasonic assessment was done with real time ultrasonographic equipment (GE Health care,LOGIC P6) having a 3.75 MHz transabdominal curvilinear probe. After carefully determining fetal situs, four chamber view was established. The transducer was moved cranially to upper mediastinum in transverse orientation of fetal chest and three vessel view was obtained demonstrating main fetal pulmonary artery, ascending aorta and superior vena cava in cross section. The cross bar of caliper was merged with the vessel wall and measurements were taken of pulmonary artery in longitudinal section and aorta in cross section. All the data was collected on the data sheet.

We used WHO sample size calculator and SPSS version 35.0 software to analyse our data. Descriptive and inferential statistical analysis was done. Pearson correlation coefficient was determined and regression analysis was used. The women were followed after birth and neonates were evaluated by neonatologist for not having any congenital heart defects at birth.

RESULTS

A total of 56 females enrolled had Mean age of 27.3 + 4.4 years (range 20 - 37 years). Details of the age group and parity of the females are shown in the table below. Majority of the patients were of the age group 21 to 30 years.

Table 1:

Age Group					
Age Group	N	Minimum	Maximum	Mean	Std. Deviation
<20	7	22.00	31.00	26.5714	3.45722
21 to 30	31	20.00	35.00	26.9032	4.57059
31 to 40	18	21.00	37.00	28.1667	4.47542
Gravida					
Age Group		Frequency	Percent	Valid Percent	Cumulative Percent
<20	MG	6	85.7	85.7	85.7

	PG	1	14.3	14.3	100.0
21 to 30	MG	23	74.2	74.2	74.2
	PG	8	25.8	25.8	100.0
31 to 40	MG	15	83.3	83.3	83.3
	PG	3	16.7	16.7	100.0

Table 2:

Fetal pulmonary artery FAP						
Gestational Age in weeks	N	Range	Minimum	Maximum	Mean	Std. Deviation
18	8	0.40	2.10	2.50	2.3500	0.13093
19	4	0.20	2.10	2.30	2.2500	0.10000
20	11	0.40	2.40	2.80	2.5727	0.13484
21	8	0.30	2.50	2.80	2.6875	0.12464
22	6	1.10	2.70	3.80	2.9500	0.42308
23	5	0.40	2.70	3.10	2.8200	0.17889
24	4	0.10	3.10	3.20	3.1500	0.05774
25	5	0.40	3.10	3.50	3.3400	0.18166
26	5	0.50	3.30	3.80	3.6000	0.18708
Fetal Aorta						
Gestational Age in weeks	N	Range	Minimum	Maximum	Mean	Std. Deviation
18	8	1.40	1.10	2.50	1.5613	0.44707
19	4	0.72	1.22	1.94	1.7300	0.34157
20	11	0.72	1.08	1.80	1.4227	0.23900
21	8	0.70	1.20	1.90	1.6413	0.22681
22	6	0.89	1.01	1.90	1.3450	0.30481
23	5	1.50	1.20	2.70	1.7080	0.58251
24	4	0.69	1.31	2.00	1.7275	0.29387
25	5	1.71	1.19	2.90	1.8820	0.68328
26	5	0.70	1.30	2.00	1.6000	0.27386

Linear Regression: According to the analysis the equation for dependent variable value that is Pulmonary Artery Diameter **is** as following

PAD= (-0.52) +0.15(GA)

Pearson correlation co efficient was found to be 0.887 which shows strong correlation between PAD and GA (p value=<0.001). R square value is 0.787 shows that 78.7 % variation is PAD could be explained by Gestational age (p value<0.001). B coefficient value of 0.15(95% CI 0.13-0.18) can be interpreted as increase in gestational age by one month can increase Fetal Pulmonary Artery Diameter by 0.15 mm.

Fetal Aorta dimeter correlation with gestational was found to be 0.164 showing weak correlation which was also insignificant. Regression analysis was also found to be insignificant with weak R square value of 0.027 and insignificant p value >0.05. So the regression equation cannot be formulated.

DISCUSSION

Antenatal identification of heart abnormalities has been linked to lower incidence of newborn illness and fatality (1, 2). A large percentage of severe cardiovascular issues with aberrant heart chamber dimensions may be detected using the four-chamber scan technique. This approach, nevertheless, is insufficient for detecting most outlet tract anomalies (3, 4) particularly those linked with roughly equal chamber dimensions. The majority of population-based investigations have indicated a low rate of prenatal identification of newborns with outflow tract anomalies (5, 6). Tertiary institutional findings are more encouraging, with greater diagnostic accuracy (7, 8).

The Routine Antenatal Diagnostic Imaging with Ultrasound (RADIUS) experiment found that the diagnostic accuracy of anatomical abnormalities in the non teaching environment is lower (9). The demonstration of the left and right ventricular outflow pathways takes more time and demands even greater expertise. A prolonged basic scan of the fetal heart should be conducted if the radiologist is capable of revealing both outflow pathways and it is physically possible, as this is linked with a higher detection rate for congenital heart diseases (10). Nevertheless, a screening programme like this may not be feasible in all nontertiary settings. Because the vast number of pregnant women (> 70%) get routine mid-trimester ultrasound scans in non-tertiary settings, a simple and practical screening tool may be beneficial (11).

Numerous researches from all over the the world, including one pioneering research done by Cartier et al., with diverse communities, have founded that readings of the foetal pulmonary artery and aorta can play a part in diagnosis of congenital heart disease, so they developed a nomogram for the foetal pulmonary artery and aorta for gestational ages between 14 and 42 weeks (12-15). Tetralogy of Fallot, aortic atresia, pulmonary atresia, and Marfan syndrome were all diagnosed as a result of inadequate vessel caliber. We tested a simple and objective strategy for screening for congenital outflow tract abnormalities in this research. The 3 vessel view (3VV) has been demonstrated to be beneficial in detecting congenital heart diseases with aberrant outflow tracts (16). To detect aberrant outflow routes on 3VV, improper vascular alignment and subjective size difference were employed.

In this investigation, the outflow tracts were evaluated using a more realistic manner. This allowed all the radiologists with varying degrees of expertise to achieve respectable detection accuracy. In the current study, 451 fetuses were assessed between the ages of 18 and 26 weeks. Cartier et al. measured the diameter of the pulmonary artery in 403 fetuses aged 14 to 42 weeks (12). Sosa-Olavarria et al. investigated 337 fetuses with GA 13-38 weeks and created a normogram of the measured diameter of pulmonary artery (17). Wong et al. studied 966 singleton babies to develop a nomogram for the fetal pulmonary artery to aortic diameter ratio (18). Ruano et al., constructed nomogram of main pulmonary artery, right and left pulmonary artery in 220 fetuses between the GA of 19 and 40 weeks (19).

The current study's 50th percentile of pulmonary artery diameter was compared to other accepted studies by Tayade et al. and Baran et al., (20, 21). With some exceptions, the 50th percentile of pulmonary artery diameter in our research corresponded with that of the pulmonary artery diameters reported by Tayade et al., and Baran et al.,. Slight variances in the findings of these three differences might be attributable to regional differences, technical differences, or sample size disparities. Because we are a Pakistani community with low constitutional weight and height, and we are also a less developed population, the measured parameters were lower in comparison to the other population.

The pulmonary artery diameter was calculated using the regression equation shown below.

PAD= (-0.52) +0.15(GA)

If the size of the pulmonary artery is given, many researches have utilised separate regression models to estimate the gestational age. Tayade et al. calculated the pulmonary artery size using the regression equation shown below.

PAD (mm) = 3.22 + 0.015 × GA

Where PAD is pulmonary artery diameter

Cartier et al., used the following regression equation for PAD against GA:

PAD (mm) = 0.320 GA−3.0

Achiron et al. discovered a good association between foetal pulmanory artery diameter and gestational age (r 2 = 0.94%) in their investigation and utilised the following regression equation for pulmonary artery as a surrogate of gestational age:

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., observed in their investigation that the size of the pulmonary artery had a significant connection with GA (22). The regression equation for pulmonary artery diameter vs gestational age was as follows:

MPA (mm) = −2.76 + 0.34 × GA (weeks)

where MPA is main pulmonary artery diameter.

Using our work, we developed a novel nomogram dedicated for our institute for predicting gestational age by fetal pulmonary artery diameter based on the regression equation. According to the

nomogram, increased gestational age results in a steady rise in pulmonary artery diameter. The average fetal pulmonary artery diameter in millimeters with a 95% confidence interval varied from 2.48 +/- 0.27 mm at 18 weeks to 4.68+/- 0.37 mm at 26weeks, with the mean diameter being 3.37+/- 0.66 mm.The diameters of fetal pulmonary artery by Tayade et al., (20) ranged from 2.48 mm at 18 weeks to 4.68 mm at 26 weeks.

At 16-20 weeks of pregnancy, the fetal pulmonary artery measured between 2.1 and 4.93 mm (mean = 3.3 mm) in a work by Wong et al., (23). The fetal PAD varied from 2.93 to 5.03 mm at 19 and 26 weeks of gestation in a research conducted by Ruano et al., (20). Hence, the nomogram of fetal PAD of the present study was comparable with that of Achiron et al, Wong et al., and Baran et al. Our research has provided regression equation based on local population which is one of a pioneer study and will provide a platform for future studies .However obtaining a proper three vessel view (3VV) is mandatory for measuring pulmonary artery and fetal aorta diameter and requires technical expertise. Further researches are needed in this subject and new regression equations should be derived for comparison.

REFERENCES

1. Wu W, He J, Shao X. Incidence and mortality trend of congenital heart disease at the global, regional, and national level, 1990-2017. Medicine (Baltimore). 2020 Jun 5;99(23):e20593. doi: 10.1097/MD.0000000000020593. PMID: 32502030; PMCID: PMC7306355.
2. Gudigar A, Raghavendra U, Samanth J et al. Role of Four-Chamber Heart Ultrasound Images in Automatic Assessment of Fetal Heart: A Systematic Understanding. Informatics. 2022.10.3390/informatics9020034.
3. Weerakkody, Y., Jones, J. Four chamber cardiac view (fetal). Reference article, Radiopaedia.org. (accessed on 04 Oct 2022) https://doi.org/10.53347/rID-15708
4. van Nisselrooij AEL, Teunissen AKK, Clur SA, Rozendaal L, Pajkrt E, Linskens IH, Rammeloo L, van Lith JMM, Blom NA, Haak MC. Why are congenital heart defects being missed? Ultrasound Obstet Gynecol. 2020 Jun;55(6):747-757. doi: 10.1002/uog.20358. PMID: 31131945; PMCID: PMC7317409.
5. Bravo-Valenzuela NJ, Peixoto AB, Araujo Júnior E. Prenatal diagnosis of congenital heart disease: A review of current knowledge. Indian Heart J. 2018 Jan-Feb;70(1):150-164. doi: 10.1016/j.ihj.2017.12.005. Epub 2017 Dec 16. PMID: 29455772; PMCID: PMC5903017.
6. Bonnet D. Impacts of prenatal diagnosis of congenital heart diseases on outcomes. Translational pediatrics. 2021;10(8):2241-9.
7. Waern M, Mellander M, Berg A, Carlsson Y. Prenatal detection of congenital heart disease - results of a Swedish screening program 2013-2017. BMC pregnancy and childbirth. 2021;21(1):579.
8. Xia Y, Wang F, Zhao Y, Liyan F, Ye C, Ji X. The value of outflow tract flow tracing in early pregnancy in the screening of structural malformations of fetal cardiac great arteries. Ann Transl Med. 2021;9(24):1791.
9. Zhang Y, Cai AL, Ren WD, Guo YJ, Zhang DY, Sun W, et al. Identification of fetal cardiac anatomy and hemodynamics: a novel enhanced screening protocol. BMC pregnancy and childbirth. 2016;16:145.
10. Suard C, Flori A, Paoli F, Loundou A, Fouilloux V, Sigaudy S, et al. Accuracy of prenatal screening for congenital heart disease in population: A retrospective study in Southern France. 2020;15(10):e0239476.
11. Sun HY, Proudfoot JA, McCandless RT. Prenatal detection of critical cardiac outflow tract anomalies remains suboptimal despite revised obstetrical imaging guidelines. Congenital heart disease. 2018;13(5):748-56.
12. Nayak K, Chandra GSN, Shetty R, Narayan PK. Evaluation of fetal echocardiography as a routine antenatal screening tool for detection of congenital heart disease. Cardiovascular diagnosis and therapy. 2016;6(1):44-9.
13. Crispín Milart PH, Prieto-Egido I, Díaz Molina CA, Martínez-Fernández A. Detection of high-risk pregnancies in low-resource settings: a case study in Guatemala. Reproductive Health. 2019;16(1):80.
14. Deden C, Neveling K, Zafeiropopoulou D, Gilissen C, Pfundt R, Rinne T, et al. Rapid whole exome sequencing in pregnancies to identify the underlying genetic cause in fetuses with congenital anomalies detected by ultrasound imaging. Prenatal Diagnosis. 2020;40(8):972-83.
15. Yeo L, Luewan S, Romero R. Fetal Intelligent Navigation Echocardiography (FINE) Detects 98% of Congenital Heart Disease. Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine. 2018;37(11):2577-93.
16. Yetwale A, Kabeto T, Biyazin T, Fenta B. Prenatal Ultrasound Utilization and Its Associated Factors among Pregnant Women in Jimma Town Public Health Institutions, Ethiopia. Health services research and managerial epidemiology. 2022;9:23333928221085881.
17. Lussier EC, Yeh SJ, Chih WL. Reference ranges and Z-scores for fetal cardiac measurements from two-dimensional echocardiography in Asian population. 2020;15(6):e0233179.
18. Comstock CH, Riggs T, Lee W, Kirk J. Pulmonary-to-aorta diameter ratio in the normal and abnormal fetal heart. American journal of obstetrics and gynecology. 1991;165(4 Pt 1):1038-44.
19. Neelavalli J, Krishnamurthy U, Jella PK, Mody SS, Yadav BK, Hendershot K, et al. Magnetic resonance angiography of fetal vasculature at 3.0 T. Eur Radiol. 2016;26(12):4570-6.
20. Cartier MS, Davidoff A, Warneke LA, Hirsh MP, Bannon S, Sutton MS, et al. The normal diameter of the fetal aorta and pulmonary artery: echocardiographic evaluation in utero. AJR American journal of roentgenology. 1987;149(5):1003-7.
21. Brandt JS, Wang E, Rychik J, Soffer D, McCann ML, Schwartz N. Utility of a Single 3-Vessel View in the Evaluation of the Ventricular Outflow Tracts. Journal of ultrasound in medicine : official journal of the American Institute of Ultrasound in Medicine. 2015;34(8):1415-21.
22. Sosa-Olavarria A, Zurita-Peralta J, Schenone CV, Schenone MH, Prieto F. Doppler evaluation of the fetal pulmonary artery pressure. Journal of Perinatal Medicine. 2019;47(2):218-21.
23. Chiu WH, Lee SM, Tung TH, Tang XM, Liu RS, Chen RC. Length to width ratio of the ductus venosus in simple screening for fetal congenital heart diseases in the second trimester. Medicine (Baltimore). 2016;95(39):e4928.
24. Garcia-Canadilla P, Rudenick PA, Crispi F, Cruz-Lemini M, Palau G, Camara O, et al. A computational model of the fetal circulation to quantify blood redistribution in intrauterine growth restriction. PLoS computational biology. 2014;10(6):e1003667.
25. Tayade AT, Singh N, Tayade S, Kale SK, Patil S. Nomogram of fetal pulmonary artery diameter in second trimester of pregnancy. INTERNATIONAL JOURNAL OF SCIENTIFIC STUDY. 2017;4(12):41-5.
26. Baran SY, Arslan A, Durdag GD, Kalayci H, Simsek SY, Alemdaroglu S. Does Larger Fetal Ascending Aorta Than the Pulmonary Artery Indicate Major Cardiac Anomaly? Gynecology Obstetrics & Reproductive Medicine. 2021;27(2):89-93.
27. Subedi K, Chataut D, Khanal U, Ansari M, Pradhan S. Inclusion of Three-Vessel View in Routine Fetal Cardiac Screening. Nepal Journal of Obstetrics and Gynaecology. 2014;9:82-6.
28. Dong S-Z, Zhu M. Pattern-based approach to fetal congenital cardiovascular anomalies using the transverse aortic arch view on prenatal cardiac MRI. Pediatric Radiology. 2015;45(5):743-50.