Journal of Cardiovascular Disease Research

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 01, 2023

ORIGINAL RESEARCH ARTICLE

ULTRASONOGRAPHIC STUDY OF FETAL AORTA, PULMONARY TRUNK ITS MORPHOMETRIC CORRELATIONS AND CLINICAL SIGNIFICANCE

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Type of Study: Original Research Paper
Date of Acceptance: 14 January 2023
Date of Publication: 31 January 2023

ABSTRACT

Background: Materno-Fetal medicine is one of the most rapidly evolving fields in medicine focusing on the medical and surgical management of high-risk pregnancies. Our present knowledge of handling high risk pregnancies is much advanced owing to non-invasive monitoring of Materno-fetal health i.e. Ultrasonography. Considering the paucity of quantitative anatomical data regarding the fetal development of outflow tract vessels, a study of morphometric analysis on fetal blood vessels was done. **Aim:** Aim of the study is to evaluate the morphometric details of Aorta (A) and Pulmonary Trunk (PT) in the human fetuses using Ultrasonographic method. The objective was to measure and correlate the internal diameters of A, PT with regard to gestational age.

Materials and Methods: IHEC approval for the study was obtained. Mothers of 50 fetuses aged between 14-36 weeks of gestation were recruited for the study from PSG Hospitals, Coimbatore. Ultrasound examination was performed with a transabdominal 2.5-5 MHz curvilinear transducer (HDI3500 or HDI5000; Siemens, USA) by experienced sonographers post consent. Freeze frame images and electronic onscreen calipers were used for measurements of fetal A, PT using PACS system. Measurements were then tabulated and analysed.

Discussion: Quantification and correlation of the developmental parameter i.e., Internal diameter of A, PTwith regard to gestational age will be discussed in detail. Established Parameters can be used as a reference chart during fetal USG examination of heart.

Keywords: Aorta (A), Pulmonary Trunk (PT), Ultrasonography (USG), Picture Archive Communicating System (PACS).

INTRODUCTION

Materno-fetal healthcare is one of the most rapidly evolving fields in medicine focusing on the medical and surgical management of high-risk pregnancies. Basic researches carried out in the fetus leads to an in-depth understanding of its structural and functional aspects eventually for the better care for pregnant mother and her growing fetus. Technical advancements of the 21st

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century in the field of surgery allows for the correction of birth defects like congenital heart disease in-utero (Anthony et al., 2014).

Hence researches carried on the developmental aspects of fetus are much relevant in clinical and surgical terms of today. Knowledge of cardiovascular system remained as a great mystery during ancient times. Our present knowledge of fetal development and mal-development is much advanced owing to non-invasive monitoring of fetal health i.e. Ultrasonography and Fetal Echocardiography (Castillo et al., 2005).

Considering the paucity of quantitative anatomical data regarding the normal developmental stages of outflow tract vessels in Tamil Nadu population, limitations met during early studies by other authors and available scientific infrastructure, a novel approach of morphometric analysis using onscreen caliper instrumentation method in Ultrasound images has been done to chart the developmental parameters which can be of use for radiological practice.

Ultrasonography plays a vital role in the understanding of fetal anatomy especially the growth of whole body and the individual organs. An initiative, to evaluate morphometrically and correlate the internal diameters of fetal aorta and pulmonary trunk which can be of practical use as reference chart to echo cardiographers is done.

Aim and Objective

Aim of the study is to chart the morphometric parameters of aorta and pulmonary trunk in the human fetuses aged between 14th to 36th weeks using ultrasonography. The objective is to quantify the strength of association between the internal diameters of Aorta and Pulmonary trunk with gestational age groups.

MATERIALS AND METHODS

Institutional Human Ethics Committee approval was obtained for the study (Proposal no.14/171). 50 Ultrasonographic images of fetuses aged between 14-36 weeks of gestation were collected from Department of Radiology, PSG Institute of Medical Science and Research, Coimbatore, Tamilnadu. Consent was obtained from parents to retrieve images from Picture Archive Communication System (PACS) and the images were collected.

Standardized protocols for USG measurements were established in concurrence with the radiologist including Inclusion and Exclusion criteria's. Grouping of fetuses was done based on the criteria of Gestational Age (GA) by Hadlock's criteria under three groups:

Group A: GA of 14-20 weeks (n=10)

Group B: GA of 21-30 weeks (n=30)

Group C: GA of 31-36 weeks (n=10)

Recorded parameters were tabulated in Microsoft Excel 2007 and data's were further entered into the software package. Statistical package for the social sciences (SPSS) for statistical analysis. ANOVA test for comparison of internal diameter of vessels with Gestational Age was done. Pearson Correlation co-efficient test was done to quantify the strength of association between the internal diameter and gestational age groups.

Ultrasound examination was performed with a transabdominal 2.5-5 MHz curvilinear transducer (HDI3500 or HDI5000; Siemens, USA) by qualified and experienced sonographers. Freeze frame images and electronic onscreen calipers were used for measurements. Measurements were taken from the widest portion of aorta, pulmonary trunk using electronic onscreen calipers.

Steps followed to take measurements from Aorta and Pulmonary trunk such as i) Three vessel view plane was obtained during routine ultrasound examination by sliding cranially from the 4 Chamber view. ii) In the transverse plane, common pulmonary trunk and aorta was identified. iii) Spatial arrangement was confirmed by identifying the pulmonary trunk and aorta which were arranged in a straight line, decreasing order in size from the left anterior to the right posterior aspect of the mediastinum.iv) Calipers were then placed on the lines that defined the

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vessel wall from the widest portion of common pulmonary trunk and the widest portion of the aortic diamete.

RESULTS

Systematic observations were carried out with multiple recordings to minimize observational bias. Grouping was done based on the criteria of Gestational Age (GA) to plot the datas in accordance with development. Further comparison of the parameters was done to plot the growth pattern curve of vessels.
Parameter of internal diameter for aorta and pulmonary trunk was recorded at different levels in Ultrasound(Fig. 1).

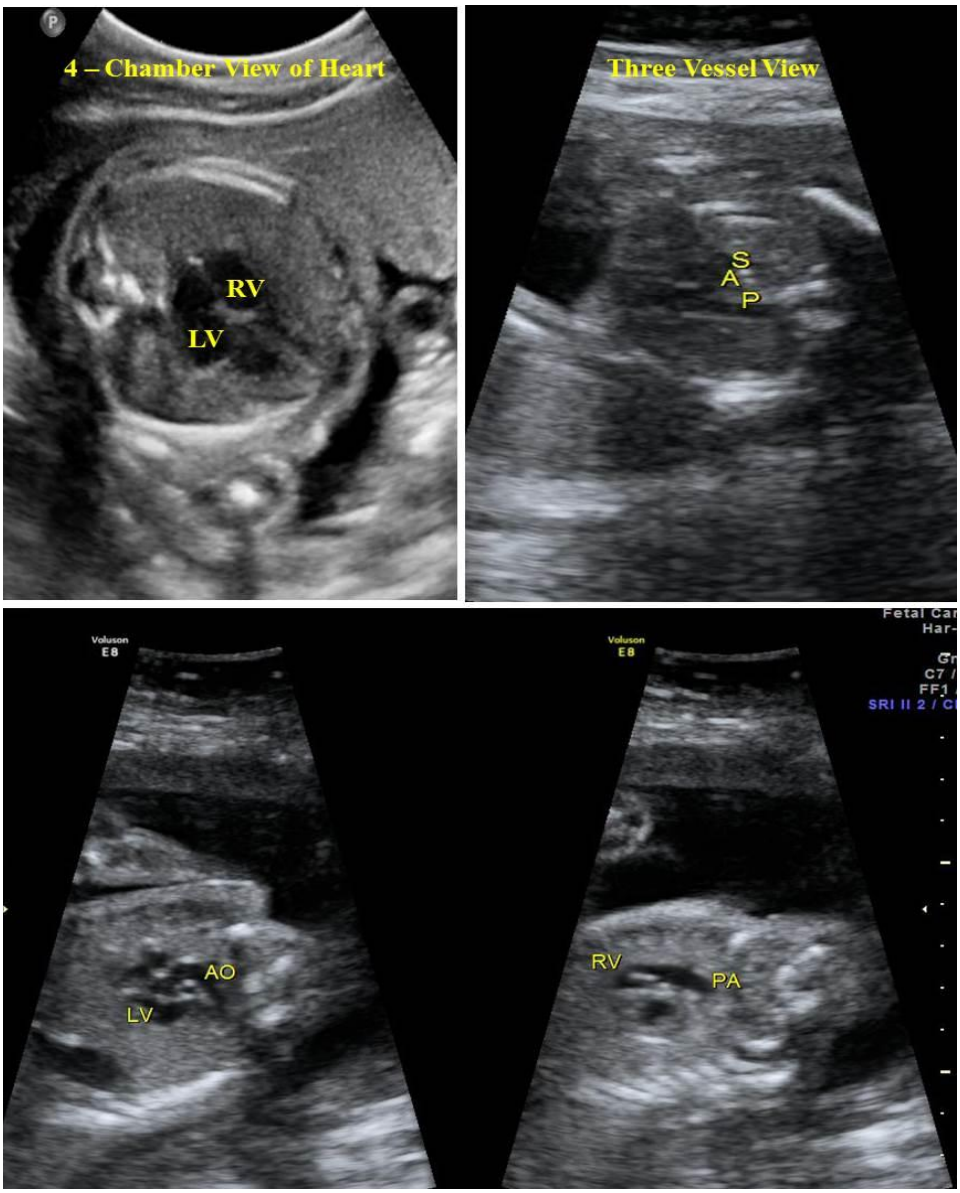

Fig.1. Ultrasonographicobservation of aorta and pulmonary trunk(RV- Right Ventricle, LV- Left Ventricle, S - SVC, A - Aorta, P - Pulmonary Trunk)

Parameter of thickness of tunica media for aorta and pulmonary trunk was observed in Carl Zeiss light microscope with Axio Cam provision and measurements under 10 x magnifications

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in millimetre scaling was done using computerized software programme Efforts have been made in the observation section to present the complex morphometric datas (Fig. 2 and Fig. 3).

Fig. 2. Morphometric measurements in-utero (29 week of gestation)

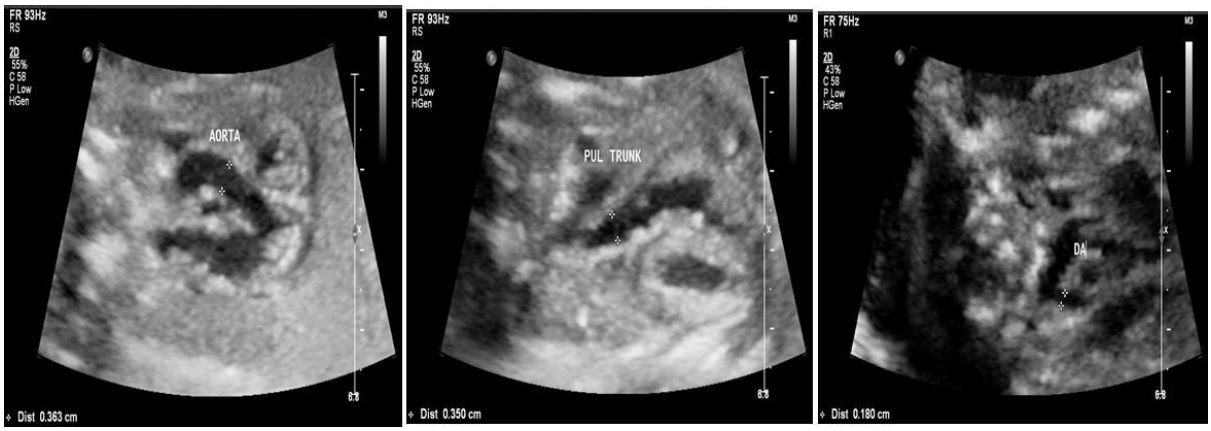

Fig. 3. Morphometric measurements in-utero (28 week of gestation)

Table 1: Relationship between the Internal diameter and Gestational Age (Group A, B & C)

	Age of the Fetus (weeks)	Mean Internal Diameter of Great Vessels (mm)		Ratio
		Aorta	Pulmonary Trunk	PT/Aorta
Group-A (N=10)	16-20	2.3	2.5	1.08
Group-B (N=30)	21-30	3.4	3.7	1.08
Group-C (N= 10)	31-36	5.7	6.5	1.14

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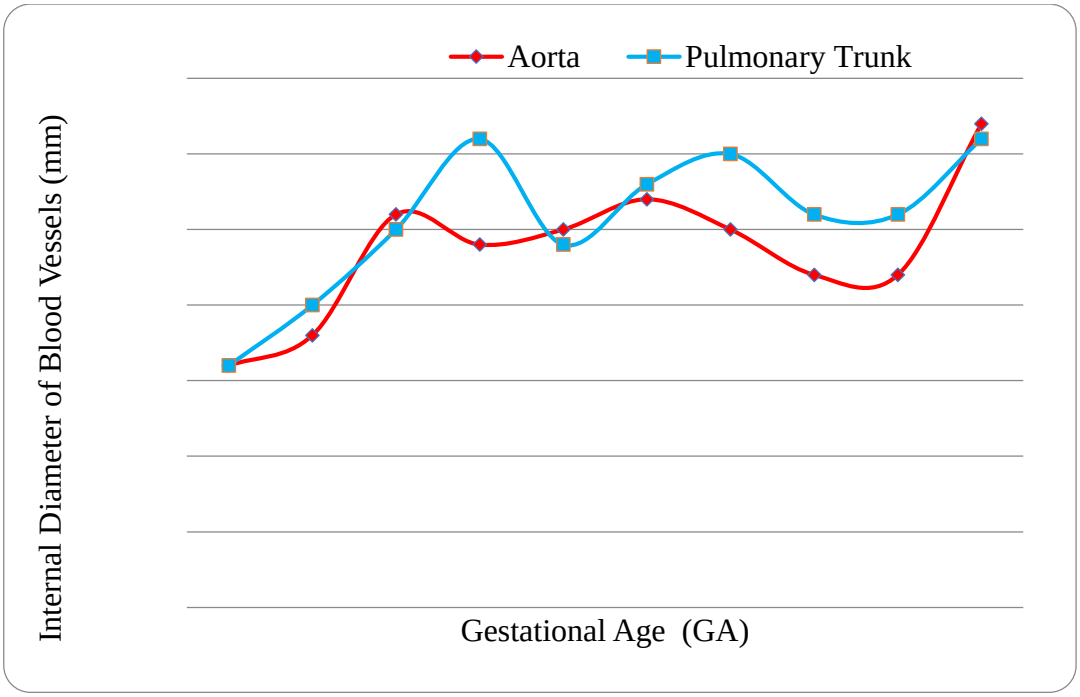

Fig. 4a.Relationship between the internal diameter and gestational age (Group A)

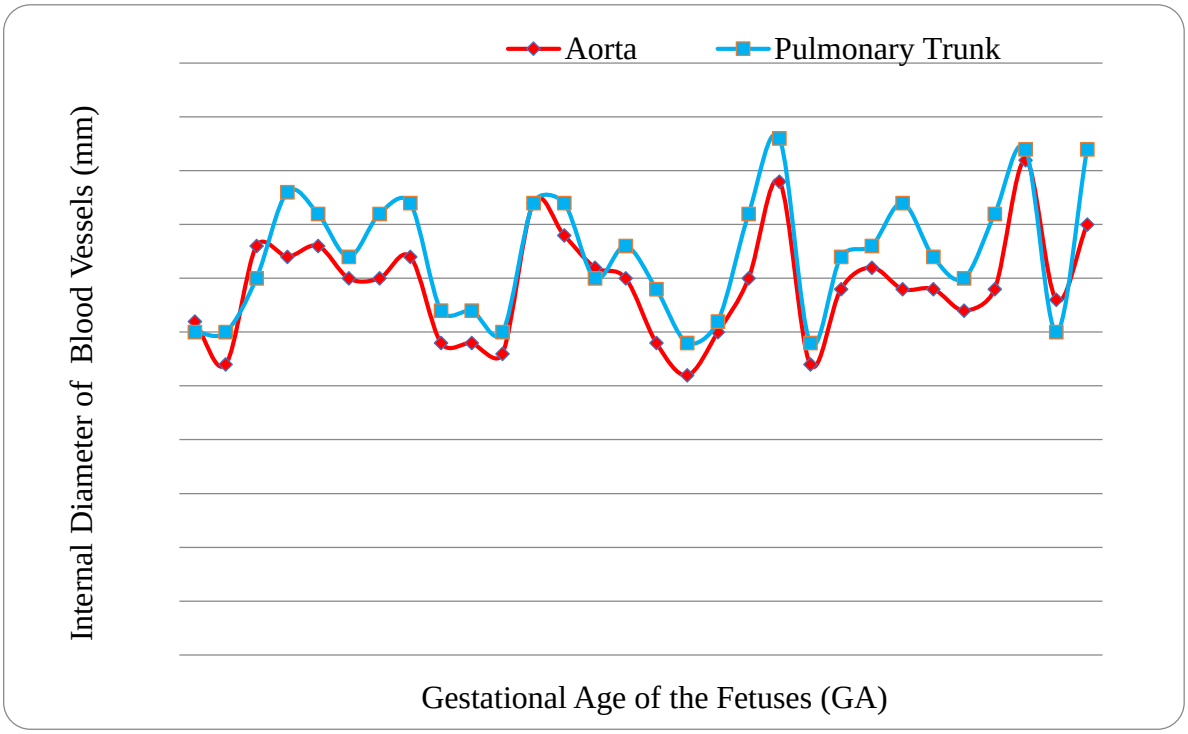

Fig. 4b.Relationship between the internal diameter and gestational age (Group B)

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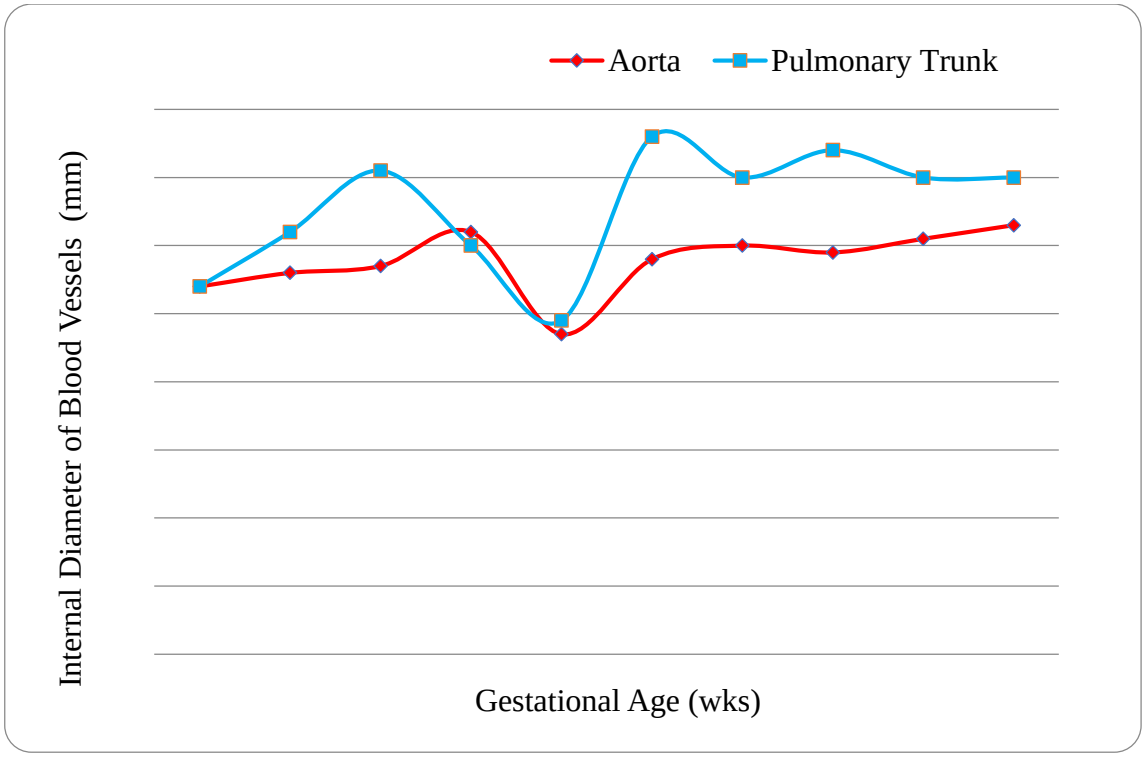

Fig. 4c.Relationship between the internal diameter and gestational age (Group C)

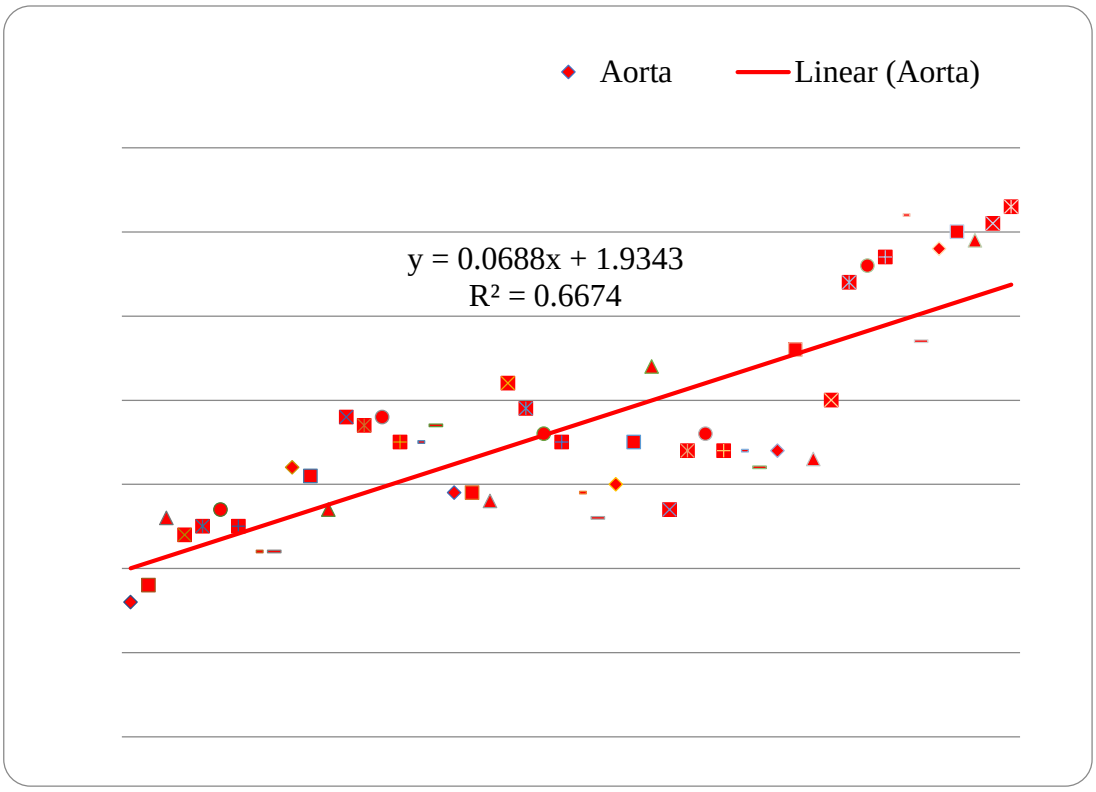

Fig. 5. Relationship between the internal diameter of aorta and gestational age

Analysis of the internal luminal diameter reveals the growth of aorta to be linear in accordance to the gestational age. With the expressed regressionequation it can be elucidated that mean value regresses just -1.1553 and +0.209 from minimum and maximum values respectively (Fig. 5).

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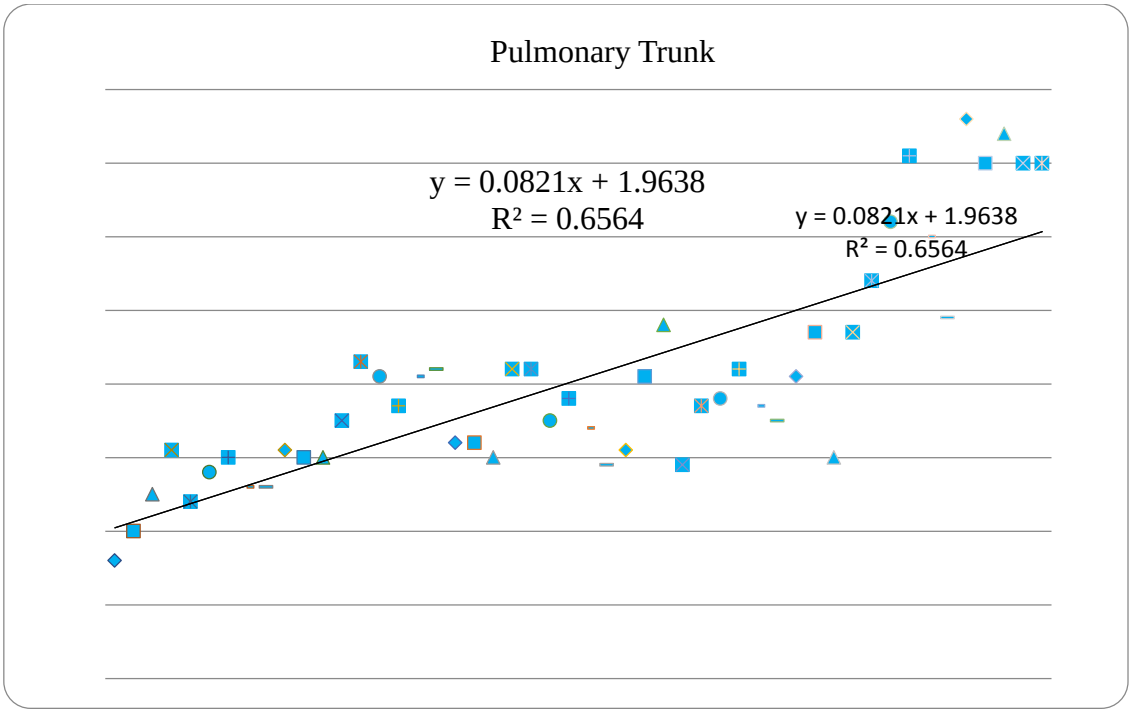

Fig. 6. Relationship between the internal diameters of pulmonary trunk and gestational age

Analysis of the internal luminal diameter reveals that the growth of the pulmonary trunk to be linear in accordance to the gestational age. With the expressed regression equation it can be elucidated that the mean value regresses -2.409 and +0.256 from min. and max. values respectively(Fig. 6).

DISCUSSION

Considering the practical difficulties encountered during short and long duration formalin fixed fetuses as strongly suggested by Ursellet al., (1991),an effort was made to evaluate the measurements using Ultrasonography.

Comparison between the mean internal diameters of Pulmonary Trunk and Aorta from 14 weeks gestation is crucial for early detection of severe cardiac and outflow tract abnormalities. In the present study mean aortic and pulmonary internal diameters were 2.3, 2.5 mm respectively for 14-20 weeks of gestation. From 21-30 weeks it was 3.4, 3.7 mm and for 31-36 weeks it is 5.7 and 6.5 mm. These measurements are in concurrence with studies conducted (Cartieret al., 1987; Ichida et al., 1987; Hornbergeret al., 1992)

Individual and ethnic variations in cardiac growth usually presents a wide scatter of normal values with values lying usually away from the regression curve. Standardisation for such a limitation is done by calculating the ratio of the pulmonary trunk to aorta for each subject which is interestingly much constant. During 16-24 weeks of pregnancy the PT/A ratio and its S.D. is 1.16 (0.18) as plotted and throughout infancy and childhood it is 1.06 (0.06) (Wong et al., 2007)

The ratio of pulmonary trunk to aorta in different age group is:

Group A: 14-20 weeks – PT/A ratio (S.D.) was 1.08.

Group B: 21-30 weeks – PT/A ratio (S.D.) was 1.08.

Group C: 31-36 weeks – PT/A ratio (S.D.) was 1.13.

Nowadays PT/A ratio is commonly used as a simple screening tool to detect outflow tract abnormalities in foetuses which is easily measured during 3 vessel view and which consumes much lesser visualisation time in expert hands.

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High correlation was found between measurements of aorta and pulmonary trunk against gestational age as derived from Karl-Pearson Co-efficient analysis which is similar to the studies of Cartier and Hornberger. Cartier and his colleagues using in Utero Echocardiographic evaluation using 2D real time during systole and diastole gave a value of r=0.994 for aorta and r=0.996 for pulmonary artery and M-mode measurements value of r=0.992 for aorta, r=0.973 for pulmonary artery (Cartier et al., 1987).Hornberger in his echocardiographic study of the morphology and growth of the aortic arches in human fetuses presented correlation coefficients for the diameter of each aortic arch segment when related to gestational age varied from r=0.87 to r=0.94 for each. In the present study the correlation coefficient for aorta and poulmonary trunk was r=0 .92 and r=0.91 respectively.

Achiron et al., (1998) in his ultrasonographic study during first half of gestation measured the Aortic diameter (AD) and Pulmonary Artery diameter (PD) with regard to gestational age (GA) of fetuses between 14-36 weeks and expressed it by the regression equation and r2 value of

AD = −1.603 +.2.256 × GA; r2 - 0.94 (High Correlation)

PD = −1.476 + 2.402 × GA; r2 - 0.94 (High Correlation)

In the present study the regression equation for aortic diameter (AD) as a function of gestational age (GA) in terms of 14-36 weeks was expressed by the regression equation and r2 value ofAD: Regression equation : -1.553+0.209 X GA; r2 -0.86 (High Correlation)

PD: Regression equation: -2.409 +0.256 X GA; r2 -0.86 (High Correlation)

Measurements of aorta and pulmonary trunk taken in ultrasound as intended addresses the paucity of quantitative anatomical data concerning the growth of these vessels and thereby justifies the need for such a study (Achiron et al., 2000; Alvarez et al., 1990). Whenever feasible it is advised to visualize the outflow tracts using the extended basic cardiac examination which is much critical for evaluation during the differential diagnosis of congenital diseases of outflow tract vessels.

Statistics

Recorded parameters were tabulated in Microsoft Excel and data's were further entered into the software package - Statistical Package for the Social Sciences (SPSS) version for statistical analysis. ANOVA test for comparison of internal diameter of vessels with Gestational Age was done.

Contribution: All authors contributed in this journal

Conflict of Interest: Nil

Financial support: Nil

Acknowledgement

The authors are supported by Department of Health Research (DHR) from the Multi-Disciplinary Research Unit (MDRU) of Government Theni Medical College & Hospital, Theni, TamilNadu during manuscript preparation, scientific communications phase.

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