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Sonographic measurement of fetal aortic size: Normative values in a sample of normal fetuses in a Lagos suburb, Southwest Nigeria

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ABSTRACT

Background: Congenital heart disease (CHD) is one of the most common congenital anomalies while prenatal ultrasound screening is a necessity even in low risk populations.
Aim: To measure fetal ascending aortic diameter (AAD) between 18 and 38 weeks of gestation in order to provide a normal reference data for the population studied.
Method: In the prospective cross sectional study, a sample of 300 healthy pregnant women was selected to undergo trans-abdominal echocardiography.
Data Collection: Logiq 3 ultrasound machine fitted with a 3.5 MHz–5 MHz variable curvilinear transducer was used for data collection.
Results: Mean AAD was 4.59 ± 1.56 mm. There was a linear relationship between AAD and gestational age (GA) while there was a strong positive correlation between AAD and GA ($r = 0.9915$).
Mean AAD for male and female fetuses was 4.60 ± 0.57 mm and 4.58 ± 0.55 mm respectively and the difference in mean AAD was not significant ($p = 0.8420$) between both sexes. Mean AAD in the study was significantly different from the mean AAD in a European and Asian studies ($p = 0.001$).
Conclusion: Trans-abdominal echocardiography carried out between the 18th and 38th week of gestation appears useful in screening for CHD especially if screening is performed by an experienced sonographer using a high resolution ultrasound machine.

Introduction

Congenital heart disease (CHD) is a common congenital abnormality. It is one of the commonest causes of morbidity and mortality among infants in the first year of life.[1] The prevalence of CHD per 1000 live births is reported to have risen steadily for a long period and it now appears to have stabilized globally with more than 1.4 million children born with CHD annually.[2] The incidence of CHD in the general population is between 0.8% and 1.0% with the incidence also very high even among patients without any risk factors for the condition.[3] There is a significant variation in the incidence of CHD in the world and CHDs are associated with spontaneous intrauterine and early postnatal demise. Furthermore, CHD significantly affects pregnancy and its outcome while early diagnosis of CHD (especially in utero) equally affects treatment planning and prognosis.[4–6]

Sonography is a quick, easy means of examining the morphology of the heart, the aorta as well as aortic outflow tract.[7,8] In fact, intra-uterine sonographic measurement of aortic diameter has been recommended as an important method of detecting most cardiac anomalies.[9] Between the 10th and 14th week of gestation, it has been reported that more significant narrowing of the aortic isthmus is associated with a higher incidence of trisomy 21 among fetuses with increased nuchal translucency.[3] Extended routine fetal examination of the basic four-chamber view of the heart should, therefore, include two relatively simple echocardiographic views at the level of the ventricular outflow tract in order to search for CHDs. Furthermore, the distal aortic arch and isthmus must also be visualised in order to detect malformations of the aortic arch and isthmus, such as coarctation, interruption and hypoplastic aortic arch.[10] A knowledge of the normal range of the size of the fetal ascending aorta is, therefore, necessary for sonographers who perform detailed screening for CHDs.

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Most growth curves for the aorta/aortic arch for Caucasian and Asian populations were described at autopsy whereas just a few have been described by fetal echocardiography which was limited to late gestation.[11,12] If data on normal values of fetal ascending aortic diameter (AAD) among Caucasian and Asian populations is sparse, it is even more sparse in Nigeria. Since it is a known fact that there is a significant difference in fetal size among different racial groups globally,[13–15] it is imperative to have population-specific normal values of fetal aortic size that can serve as a reference data which can aid accurate detection of fetuses at high risk of CHD. Sonographic measurement of the fetal AAD between the 18th and 38th week of gestation is known to improve prenatal diagnosis of structural anomalies of the ascending aorta and thereby allow new insights into the epidemiology and management of CHDs.[16] In the present study, therefore, we performed trans-abdominal echocardiography and measured AAD in utero between the 18th and 38th week of gestation in order to establish a normal reference range for aortic diameter for a population of fetuses in Ajah, a suburb of Lagos, Southwest Nigeria.

Subjects and methods

The prospective cross sectional study was carried out between April 2015 and January 2016. A sample of 300 pregnant women was selected. All pregnant women who came for routine antenatal ultrasound examination were approached and the research methods were explained to them. Those who agreed to participate in the study, completed and signed the consent form were recruited. Before the study commenced, the health research and ethics committee of the Lagos State ministry of health approved the research proposal.

Subject inclusion criteria

Only healthy pregnant women with a history of regular menstruation with 28-days cycle and who were sure of the date of onset of their last menstrual period (LMP) were included. Standardized sonographic measurement of crown rump length (CRL) that was performed between nine plus zero (9 + 0) and 14 + 0 weeks was used to determine the accuracy of gestational age (GA) calculated using LMP. Gestational age (GA) calculated from LMP is accurate if the difference in GA calculated using LMP and CRL is 7 days or less.[17] Only women with singleton pregnancy were recruited. Moreover, those with clinical suspicion of congenital anomaly on their ultrasound request cards were excluded while any fetus with sonographically detected anomaly was not included in the study.

Data collection

All sonographic examinations were performed by an experienced sonographer using an ultrasound machine with color Doppler facility and fitted with a variable 3.5 MHz–5 MHz curvilinear transducer (Logiq 3 Ultrasound scanner; model AY-15CUI manufactured by General Electric Company [GEC], ANY Corporation, South Korea) for measurement of fetal biometric parameters and sonographic echocardiography respectively. In a similar study, GA was determined by sonographic measurement of biparietal diameter (BPD), femur length (FL) and abdominal circumference (AC).[18] The parasternal long axis approach with slight angulation and clockwise rotation of the probe was adopted to allow optimal real time viewing of the four-chambers of the pulsating fetal heart.[19,20] Images were captured at end-diastole when the aorta reaches its maximal dilatation. At end-diastole, the mitral valve closes and the left ventricle allows greater pressure in the aorta by permitting greater flow of blood into it.[3,4,19,21] In line with the technique described by Ohuma et al. (2013), measurements were carried out between the 18th and 38th week of gestation.[18]

Measurement of fetal aortic diameter

Only one of the researchers (CIE) carried out all measurements at the ultrasound unit of Image Planet Medical Diagnostic Centre, Ajah-Lagos. To ensure that measurements were reliable, 20 subjects were randomly selected and fetal AAD was measured among them before the study began. The mean was calculated and deviation of each AAD from the mean was not statistically significant so intra-observer error did not adversely affect measurements in the study.

The left parasternal long axis imaging of the fetal heart was utilized to allow for real time viewing of the moving heart in cross-section.[19] A 4-chamber image of the heart was obtained at a level slightly above the aortic valves in the long-axis when vessel walls were perpendicular or nearly perpendicular to the ultrasound beam. Images were frozen and captured at end-diastole when the ventricles and aorta have all attained maximal dilatation.[4] The cine loop, freeze-frame capability and electronic on-screen calliper were used for image capture and measurement of aortic diameter respectively.[20,22]

Ascending aortic diameter (AAD) was measured between the inner walls.[4] Measurement of aortic diameter is shown in Fig. 1. Three measurements were made at different points in the aorta and the mean value was recorded. A computer flash drive was later used to copy data stored in the memory of the ultrasound machine from where they were transcribed into a computer.

Data analysis

Descriptive and inferential statistics were calculated. The mean ± standard deviation (SD) was calculated for the population, for each week, and for male and female fetuses. Paired t-test was used to compare the mean AAD for male and female fetuses. Measured AAD were plotted against GA so as to show the nature of relationship between AAD and GA. Moreover, Pearson's correlation coefficient (r) was used to determine extent and direction of relationship between AAD and GA. Simple regression analysis was used to produce a normogram for the population. Unpaired t-test was used to compare mean AAD in the population with that of other populations. Results were tested for their statistical significance at

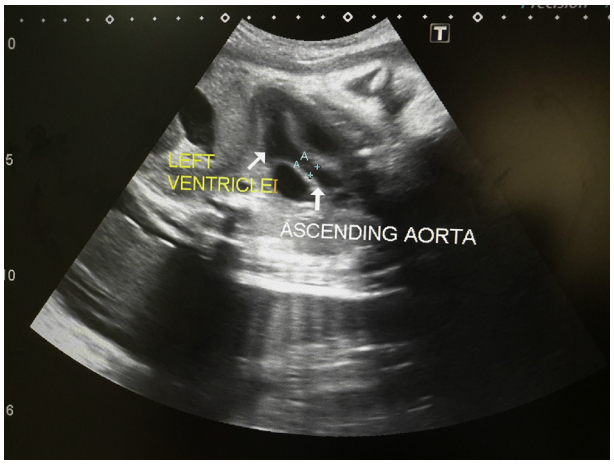

Figure 1. Sonogram showing measurement of ascending aortic diameter; AA = Ascending aorta; distance between the two cross heads = aortic diameter.