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Original Research Article

The study of the humerus and femur length as combined predictors of the gestational age of human fetuses using ultrasonography

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ABSTRACT

Background: Ultrasound dating of pregnancy is the most effective and easiest method presently used to assess the gestational age of fetus. The study evaluates the diaphyseal lengths of humerus and femur as combined parameters to estimate the gestational age of the fetus at the time of examination.
Methods: The study was done on 152 pregnant women of gestational age from 15 to 40 weeks attending antenatal clinic of a certain medical college hospital. Subjects with maternal disease known to affect normal fetal growth, history of recurrent miscarriages and of chronic medications, multiple gestations or other complications and major fetal abnormalities were excluded. The diaphyseal lengths of humerus and femur were measured in a standardized manner. The relationship of the humerus and femur length in centimeters is compared with the gestational age in weeks. The multiple correlation equation of humerus and femur length with the gestational age was deduced.
Results: It was observed that the diaphyseal length of humerus and femur gradually increased from 15 weeks to 40 weeks of gestation and by applying multiple correlation, a formula was derived to calculate the gestational age.
Conclusions: The measurement of the humerus and femur length (in cm) can be an important additional parameter for estimating gestational age along with other parameters and can be used to predict the gestational age of fetuses belonging to that geographical area using the derived formula.

Keywords: Down's syndrome, Femur, Fetal growth retardation, Fetus, Gestational age, Humerus, Ultrasonography

INTRODUCTION

Fetal growth is defined as the time dependent changes in body dimensions that occur throughout the tenure of pregnancy.[1] Research into the developmental origins of health and disease has focused attention on fetal development as a determinant of lifelong health and capacity. Size and body proportions at birth predict short and long term outcomes, from infant mortality through childhood growth and cognitive ability, to diseases in adult life such as type 2 diabetes mellitus and cardiovascular diseases.[2] The value of ultrasound in dating of pregnancies has long been recognized particularly when there is uncertainty regarding the date of the last menstrual period.[3]

The 1st and 2nd trimester ultrasound is most commonly used for gestational dating, detection of fetal aneuploidy, identification of early fetal intrauterine growth restriction and assessment of cervical incompetence.

In 2nd and 3rd trimester bi-parietal diameter, head circumference, trans-cerebellar diameter, abdominal circumference, femur length and other long bones such as

tibia and humerus are useful. Fetal biometry of long bones is also useful in identifying fetuses at risk for fetal aneuploidy.[4] Several studies have shown a significant reduction in variability of gestational age estimates when mathematical modelling from multiple parameters (biometric) is employed.[5]

Both customization of fetal size charts and the assessment of fetal growth velocity have been developed to improve the ability of fetal biometry to detect high risk fetuses. However, at the screening level the use of cross-sectional reference charts and equations with the closest distribution to that of the screened population remains the gold standard. The use of cross-sectional charts remains the first line screening tool for growth abnormalities. It is well accepted that the chart used for fetal biometry should be adapted to the population studied. The assessment of fetal biometry is widely dependent upon the choice of the reference charts and equations. This enables improved identification of at risk fetuses which in turn should facilitate counselling and make better use of resources.[6]

Prenatal measurement of fetal parameters and estimated age and weights vary among different populations, depending upon their racial, demographic characteristics and nutrition. It is therefore important that fetal biometry is performed for local population and local charts of normal biometry be constructed and followed these populations and ethnic group. Fetal biometry with the help of ultrasound scanning provides the most reliable and important information about the fetal growth and well being.[1]

Limbs are traditionally assessed during pregnancy as markers of fetal growth, nutrition, and gestational age. However, evaluation of fetal limbs and identification of abnormalities may also aid in the diagnosis of various chromosomal and non-chromosomal conditions as well as narrow the differential diagnosis in cases where associated abnormalities have also been identified.[7]

Because of its size, visibility, ease of measurement and less mobility than distal limb bones, the femur and humerus are preferred over other long bones as a means of predicting menstrual age.[8]

Objective of the study

The objective of the study was to evaluate the humerus and femur length of fetus, as a combined parameter to estimate the gestational age of the fetus through routine obstetric ultrasonography.

METHODS

Source of data

The study was done in the Department of Obstetrics and Gynecology of a certain medical college hospital and included 152 pregnant women attending antenatal clinic during the period of study from December 2010 to January 2012. The fetuses of 15 to 40 weeks of gestation were considered. The research subjects were invited to participate under informed consent that was approved by Institutional Ethical Committee. The other demographic data were also collected at the time of examination including maternal age, height, weight, educational and occupational status. The measurements were done by experienced radiologist in a standardized manner.

Inclusion criteria

The fetuses of singleton pregnancies without gross structural abnormalities were included. All research subjects were healthy Indian women from the District of Dharwad in order to represent this particular geography. The study included pregnant women of age 20 to 30 years with weight of 50 to 60 kgs and height of 5ft and 5ft 6 inches (5’6”). All participants had uncomplicated pregnancies with intact fetal membranes, normal amniotic fluid volume and absence of labor at the time of examination.

Exclusion criteria

The cases of maternal disease known to affect normal fetal growth such as chronic hypertension, gestational diabetes mellitus, anemia, hypothyroidism, etc. and history of recurrent miscarriages and of chronic medications were excluded. Repeat measurement on same fetus was avoided.

Instruments used

The grey scale real time ultrasonography was performed using a PHILIPS- HD6 Ultrasound System with a 3.5 MHz curvilinear transducer (C5-2 Broadband Curved Array Transducer). The images were printed using thermal printer (Figure 1). All measurements were done using electronic calipers.

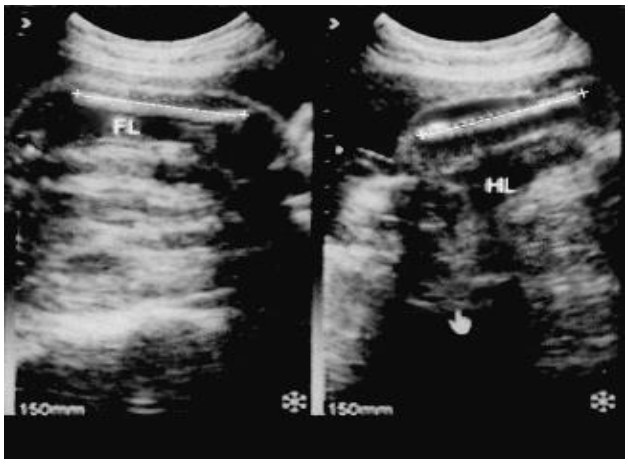

Figure 1: Ultrasonographic image of femur and humerus length.

Statistical analysis

A pilot study was conducted with 100 subjects and the sample size was calculated to be 27 [sample size = 4* variance / L2]. Therefore, after adding 10% [2.7], the sample size is 29.7 rounded off to 30 subjects. But 152 cases were included because, as larger the sample size is, greater precision does the resulting conclusions have. The correlation and regression analysis has been carried out to quantify the relationship between the gestational age in weeks and FL and HL in cm. The SPSS 10.0 and ANOVA statistical software were used for the analysis of the data and Microsoft Word and Excel have been used to generate graphs, tables etc.

RESULTS

The multiple linear regression analysis was applied to assess the dependent variable, gestational age by independent variables humerus length and femur length. The multiple regression coefficient constant was 5.271. The multiple regression coefficient for HL was 1.777 and that for FL was 2.908 as shown in the Table 1. The multiple regression equation can be derived in the form of y= a + b1x1 + b2x2, where 'y' is the dependent variable, 'a' is the regression coefficient constant, b1 and b2 are the regression coefficients for independent variables HL and FL. The x1 and x2 are the independent variables HL and FL itself i.e. GA= a + b1[HL] + b2 [FL], where GA is the gestational age in weeks and HL and FL are the diaphyseal lengths of humerus and femur in cm respectively. Therefore, GA = 5.271 + 1.777 [HL] + 2.908 [FL]. Hence the gestational age can be estimated by the derived formula. The influence or impact of Humerus and femur length is found to be significant and positive on gestational age ($p<0.05$). Further, the regression model is found to be significant with multiple regression R=0.9901 at 5% level ($p<0.05$). In other words, both Humerus and Femur lengths are considered as the best combined predictors of gestational age.

Table 1: Multiple linear regression of the gestational age by the diaphyseal lengths of humerus and femur [in cm] in total samples.

Independent variables	Regression coefficient	SE of regression coefficient	t-value	P-value	R-value	F-value	P-value
Constant	5.271	0.349	15.116	0.000*	0.990	3681.6	0.000*
Humerus length	1.777	0.533	3.333	0.001*			
Femur length	2.908	0.442	6.586	0.000*			

Regression equation GA= 5.271+1.777 (HL)+2.908 (FL); *p<0.05.

DISCUSSION

Fetal biometry is an important part of routine examination in the 2nd and 3rd trimesters of pregnancy. Fetal measurements can be combined in order to estimate the fetal weight or can be compared to previous measurements in the same fetus in order to evaluate fetal growth longitudinally. Fetal biometry is therefore used as screening test to identify fetuses that are below or above cut-off values for normality and thus are at increased risk for biometric and morphological abnormalities.[6]

In the present study shows that both humerus and femur length can be used together to predict and evaluate the gestational age more accurately.

Rosati P et al studied the relationship of femur and humerus length with GA. Linear equations turned out to be the best models for describing the relationship between femur (EFL = –16.92108 + 0.4569402 × BPD + 0.171617 × GA) or humerus length (EHL = –16.28531 + 0.4283019 × BPD + 0.1696017 × GA) vs. BPD and GA for the sample group of 400 fetuses.[9]

Zorzoli A et al measured the fetal humerus, radius/ulna, femur, tibia/fibula, and foot in 296 pregnant women at 64-108 days gestational age, using vaginal sonography. Limb measurements correlated significantly with gestational age, the best description being achieved by a linear regression for all segments. Multiple regression showed that each limb bone correlated independently with both GA and BPD, FL= -8.26 + 0.0669 GA + 0.537 BPD and HL = - 10.1 + 0.0715 GA + 0.596 BPD where GA is in days and FL, HL and BPD are in mm.[10]

Exacoustos C et al studied the growth patterns of fetal limbs, measurements of femur, humerus, tibia, fibula, radius and ulna made by ultrasound and related it to gestational age in 2317 normal singleton pregnancies at 13 to 40 weeks of gestation. The regression analysis was used to establish relationships between long bone length and gestational age. The second-degree polynomial equation turned out to be the best model describing the relationship between femur length (FL= -37.15 + 4.159 GA – 0.033 GA^2; r = 0.994; residual SD= 2.085; P< 0.0001), humerus length (HL = -36.468 + 3.739 GA – 0.039 GA^2; r = 0.993; residual SD= 1.975; $p<0.0001$) and gestational age in weeks.[11]

In present study the multiple linear regression equation derived for the calculation of the gestational age using the humerus and femur length is GA = 5.271 + 1.777 [HL] + 2.908 [FL], where GA is the gestational age in weeks and HL and FL are humerus and femur length in cm respectively.

The significance of relationship between femur and humerus length and gestational age does not vary with the occupational status and parity of the mother similar to other studies.[6,12-18] Accurate pregnancy dating is important to establish gestational age for evaluation of fetal growth and prediction of the date of delivery.[8]

Fetal biometry is of great interest in obstetrical practice. It is helpful in the estimation of gestational age especially in the women who do not remember the dates of their last menstrual period or whose fundal height on abdominal examination does not correspond to dates. The practice of assessing gestational age in early gestation is valuable in detection of growth aberration in later stages of pregnancy. In addition, fetal biometry distinguishes the normal from abnormal fetal structures. The ultimate goal of fetal biometry is to enable the user to predict information concerning a fetus and to verify how closely the fetus confirms to the prediction.[1]

The study has certain limitations like the accuracy of measurements of femur and humerus length depends on making a perpendicular scan of the long bones and care should be taken during measuring and interpreting it. The long bone length may vary among different population. Population specific normograms can be constructed from large sample sizes.

CONCLUSION

The measurement of the humerus and femur length (in cm) can be an important additional and combined parameter for estimating gestational age along with other parameters and can be used to predict the gestational age of fetuses belonging to that geographical area using the derived formula. Normograms of humerus and femur lengths can be constructed by the formula derived by this study for that particular geographical area. Sonographic measurement of diaphyseal lengths of humerus and femur is relatively simple and is clinically useful. It enables the evaluation and detection of fetal growth abnormalities that can significantly affect the management and outcome of pregnancy. Determining the diaphyseal lengths of humerus and femur may be helpful in the diagnosis of abnormalities; short humerus is seen in Down syndrome; shortened and abnormal long bones are seen in skeletal dysplasias and intra uterine growth restrictions. Increased lengths are observed in macrosomia of varied causes.

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