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International Journal of Current Research
Vol. 9, Issue, 09, pp.58217-58220, September, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

ULTRASONOGRAPHIC STUDY OF FETAL PARAMETERS AND ASSESSMENT OF GESTATIONAL AGE IN NORTH INDIAN WOMEN

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ARTICLE INFO

Article History:
Received 20th June, 2017
Received in revised form
11th July, 2017
Accepted 07th August, 2017
Published online 30th September, 2017

Key words:
Ultrasound dating,
Fetal biometry,
North Indian population,
IUGR.

ABSTRACT

Introduction: Precise sonographic assessment of gestational age and fetal growth based on population specific references is essential for optimal obstetric management. This cross sectional study was conducted to establish ultrasound dating formulae in specified North Indian population.
Methods: Fetal parameters in 583 singleton pregnant females were ultrasonographically measured for subsequent statistical analysis.
Results: The means and standard deviations of biparietal diameter, head circumference, abdominal circumference and femur length for each gestational age (derived from LMP) were calculated. *Cubic Regression Equations* were derived for each fetal sonographic parameter and a population specific dating formula was prepared.
Discussion: North Indian fetuses are smaller than European fetuses even before 3rd trimester and gestational ages derived from sonographic Western reference equations are underestimated in this population. Hence IUGR is diagnosed frequently, suggesting the need of population specific formulae and charts. This cross sectional study is an endeavor to establish population specific fetal biometric parameters for assessment of appropriate gestational age and fetal monitoring.

Citation: Badal Singh, Hina Kausar, Krishna Pandey, Anand, C., Alok Tripathi and Aditya Pratap Singh, 2017. "Ultrasonographic Study of Fetal Parameters and Assessment of Gestational Age in North Indian Women", *International Journal of Current Research*, 9, (09), 58217-58220.

INTRODUCTION

Size and body proportions at birth predict short and long-term outcomes. The main determinant of perinatal mortality is low birth weight. As low birth weight can be caused by preterm delivery and/or IUGR, accurate assessment of fetal growth is a principal aim in antenatal care. Several development indicators e.g. Biparietal diameter (BPD), Head circumference (HC), Abdominal circumference (AC) and Femur length (FL) are used to predict the Gestational age (GA), when compared with standard charts, derived in white populations of developed countries, preloaded into ultrasound machines for ready references (Campbell *et al*., 1985). Birth size, however, is a crude summary measure of fetal growth, and two neonates of identical birth weight may have followed different growth trajectories (Drooger *et al*., 2005; Yajnik *et al*., 2003). For example, mean full-term birth weight of Indian neonates is 2.6-2.9 kg compared with 3.5-3.7 kg for white populations.

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But they are not proportionately smaller in all body measurements. Thus, use of charts derived from a different population may lead to errors in diagnosis of GA and over-diagnosis of IUGR (Kinare *et al*., 2010; Singh, 2012). Number of studies has indicated that western references are clearly inadequate in Indian population and suggested the need of population specific dating formulae for appropriate obstetric management (Kinare *et al*., 2010; Singh, 2012). The objectives of this study are to derive best fit regression equations correlating the GA with BPD, HC, AC and FL from 14 weeks of GA onwards and to develop a dating formula specific to North Indian pregnant females.

MATERIALS AND METHODS

A total of 583 singleton normal pregnant females from specified North Indian population were enrolled after they met inclusion criteria. All fetal BPD, HC, AC and FL measurements were taken by experienced doctors using Siemens G-50 and GE Logiq 400 pro ultrasound machines equipped with 3.5 MHz curvilinear trans-abdominal probe in

Subharti Medical College, Meerut and other hospitals covering the population around Delhi and NCR. BPD and Occipito-frontal diameter (OFD) were measured on a transverse axial plane of the fetal head lied above the cerebellum and midbrain which intersected the cavum septum pellucidum anteriorly in the midline, the thalami and the choroid plexus in the antrum of each lateral ventricle. The BPD is measured from the outer edge of the nearer parietal bone to the inner edge of the more distant parietal bone (Hadlock *et al*., 1982; Shepard, 1982) (Fig. 1.A) and OFD is measured perpendicular to the BPD, mid skull to mid skull (Fig. 1.B). The results of the measurements were stored and head circumference calculated independently using the formula (HC = (BPD + OFD) x 1.57). AC was measured in a symmetrical, transverse, round section through the abdomen in a plane with the stomach and the bifurcation of the umbilical and hepatic veins, with visualization of the vertebrae on a lateral position in alignment with the ribs (Fig. 1.C). FL was measured by aligning the transducer with longest axis of the femur from one end of the diaphysis to another and the straight lateral surface is measured rather than medial surface which is bowed (Fig. 1.D).

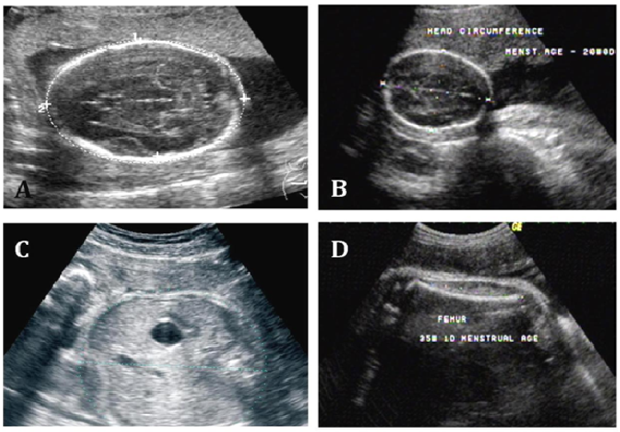

Fig. 1. Photograph showing ultrasonographic planes for measurement of (A) Biparietal diameter, (B) Head circumference, (C) Abdominal circumference and (D) Femur Length

Statistical Analysis

The descriptive statistics of each fetal parameter (mean and standard deviation) were calculated for every week of GA and charting was done to show the observational data (Table 1). Scattergrams were plotted to describe the correlation between fetal parameters and GA. Regression equation was derived as a population specific sonographic dating formula.

OBSERVATION

We used only GA derived from LMP dates rather than sonographic gestation because the latter assumes nearly identical growth in all fetuses and simply translates a measure of size into a gestational age using reference data. For the purpose of statistical study, adjustments have been made to get the GA in complete figures as: *"10wks 4days to 11wks 3days"= 11 wks.* Fetal biometric parameter (BPD, HC, AC and FL) measurements were tabulated against corresponding menstrual age (GA) and mean BPD for every completed GA; Mean and Standard-Deviation (SD) were calculated for every fetal parameter on MS-Excel sheet with the help of formula:

❖ $SD = \sqrt{\sum (X - \bar{X})^2 / n}$

Where X = any Fetal Parameter Value
$\bar{X}$= mean of Fetal Parametern = sample size

❖ $SD = \sqrt{\sum (X - \bar{X})^2 / (n - 1)}$
When sample size is less than 30.

Resultant means and their standard deviations for every fetal sonographic parameter are tabulated against corresponding GA and depicted in Table 1. Biomedical research often seeks to establish if there is a relationship between two variables; eg. BPD and GA. The methods used to do this are *correlational techniques*, which can be of two basic kinds:

- **Correlation:** used to establish and quantify the strength and direction of the relationship between two variables. It can be presented graphically in the form of *scattergram.*
- **Regression:** used to express the *functional relationship* between variables, so that the value of one variable can be predicted from the knowledge of the other. The regression line is actually the same "line of best fit" to the scattergram and regression lines can be represented by respective equations and $\mathbf{R^2}$ = Coefficient of determination (expresses proportion of variance in Y for variance in X). We can select linear, square, cubic or quadratic regression equations simply with the help of R^2 in the scattergram.

In this study, the correlation between fetal parameters and GA are shown in scattergrams of Figure 2, 3, 4 and 5 along with regression equations and R^2.

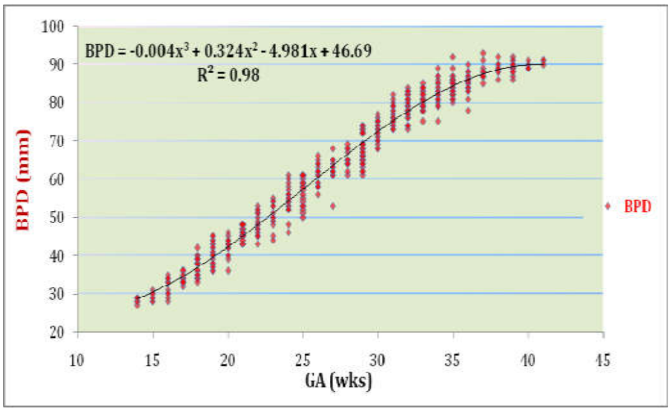

Fig. 2. Scattergram showing strong and positive correlation between Biparietal Diameter (BPD) and Gestational Age (GA).

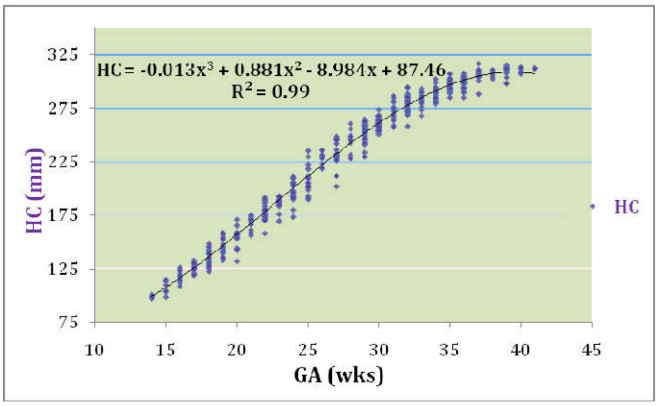

Fig. 3. Scattergram showing strong and positive correlation between Head Circumference (HC) and Gestational Age (GA)

Table 1. Showing Mean Biparietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference and Femur Length (FL) along with their Standard Deviations (SD) for corresponding Gestational Age (GA)

Menstrual age (GA)	No. of subjects	(BPD) mm ± SD	(HC) mm ± SD	(AC) mm ± SD	(FL) mm ± SD
14	6	28.33 ±0.82	99.5 ±1.56	86 ±1.05	15 ±0.41
15	7	29.29 ±1.11	108.29 ±6.68	91.71 ±5.06	16 ±1.00
16	13	32.08 ±2.22	118.46 ±5.74	100 ±5.42	17.69 ±1.44
17	11	33.91 ±1.30	126.09 ±4.28	105.27 ±3.98	19.18 ±1.47
18	23	37.09 ±2.39	135.04 ±7.38	114.96 ±8.11	22.17 ±2.35
19	27	40.04 ±2.70	146.04 ±8.21	123.7 ±6.60	25.63 ±2.65
20	19	42.47 ±2.34	153.95 ±8.70	132.16 ±6.92	27.37 ±2.91
21	23	45.91 ±1.50	169.09 ±5.34	144.96 ±5.86	31.17 ±1.67
22	25	47.96 ±2.59	177.88 ±7.80	152.24 ±6.42	33.32 ±1.35
23	13	50.38 ±3.43	185.92 ±6.80	157.92 ±5.02	34 ±2.08
24	24	54.21 ±3.44	197.71 ±9.35	166.17 ±8.91	36.88 ±3.15
25	17	56.35 ±3.67	207.47 ±12.77	175 ±10.28	39.59 ±3.34
26	21	61.14 ±2.63	228.86 ±5.30	183.05 ±2.54	42.96 ±1.40
27	20	62.25 ±2.75	230.9 ±11.85	184.2 ±6.81	43.15 ±1.63
28	12	65.17 ±2.44	244.08 ±10.37	193.17 ±8.35	44.08 ±1.83
29	35	67.57 ±3.76	252.49 ±9.02	208.69 ±14.20	47.23 ±3.46
30	27	72.85 ±2.48	260.74 ±5.24	229.19 ±9.80	52.22 ±2.56
31	33	76.45 ±2.40	272.06 ±8.36	252.27 ±10.45	56.42 ±1.89
32	37	79.11 ±2.79	280.22 ±7.58	262.65 ±6.61	57.68 ±1.84
33	30	80.6 ±2.27	283.6 ±5.73	267.37 ±4.60	60.5 ±2.52
34	38	82.39 ±2.54	288.76 ±5.09	274.92 ±7.68	62.29 ±2.37
35	33	84.21 ±2.43	295.67 ±5.40	283.15 ±6.69	64.45 ±2.25
36	42	84.98 ±2.02	298.00 ±5.13	288.57 ±6.00	65.33 ±2.41
37	11	88.09 ±2.21	306.09 ±7.31	294.36 ±9.10	67.91 ±2.39
38	11	89.18 ±1.54	307.64 ±3.17	299.45 ±3.56	69 ±1.84
39	14	89.29 ±1.64	309.29 ±5.55	299.54 ±4.01	69.45 ±1.08
40	8	89.5 ±0.76	310.38 ±2.45	302.13 ±5.59	70 ±2.39

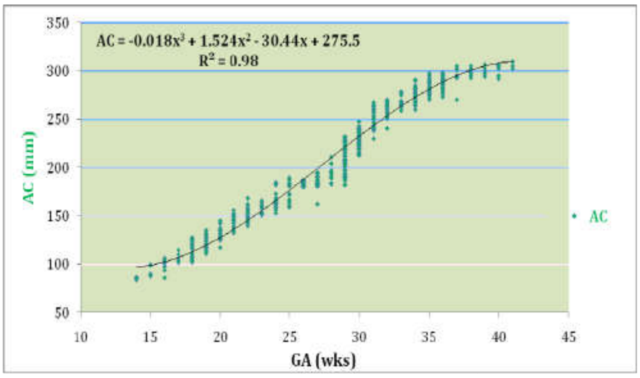

Fig. 4. Scattergram showing strong and positive correlation between Abdominal Circumference (AC) and Gestational Age (GA)

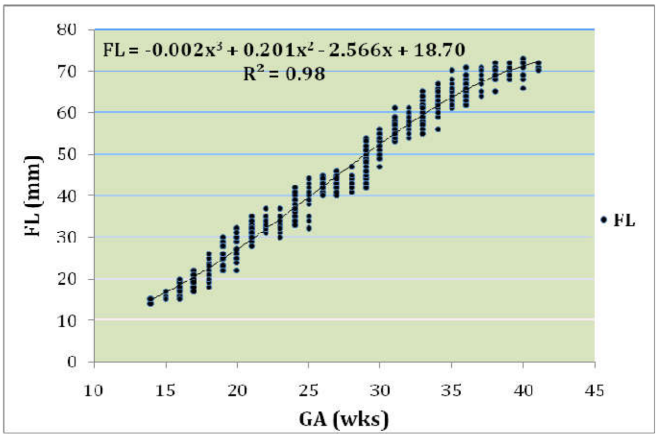

Fig. 5. Scattergram showing strong and positive correlation between Femur Length (FL) and Gestational Age (GA)

Depending on coefficient of determination (R^2), we have selected the *Cubic Regression equations* to quantify the correlation between individual fetal sonographic parameter and GA as follows:

$BPD = -0.004GA^3+0.324GA^2-4.981GA+46.69 R^2=98\%$
$HC = -0.013GA^3+0.881GA^2-8.984GA+87.46 R^2=99\%$
$AC = -0.018GA^3+1.524GA^2-30.44GA+275.5 R^2=98\%$
$FL = -0.002GA^3+0.201GA^2-2.566GA+18.70 R^2=98\%$

Taking the inference from all the observations, a common Regression Equation is prepared for ultrasonographic dating of pregnancy in our study population which can be used to develop population specific nomogram.

"GA=6.122+0.028BPD+0.029HC+0.032AC+0.144FL"

DISCUSSION AND CONCLUSION

Accurate assessment of GA by sonography can be of great importance in management decisions during pregnancy. Even in women with reliable dates, errors in gestation calculation can arise; therefore, ultrasound predictions from a regression line should be more accurate (Nguyen *et al.*, 1999). Hadlock *et al.* suggested the use of combination of multiple fetal parameters (BPD, HC, AC and FL) for better (P=0.05) age estimation or pregnancy dating than using any single parameter alone (Hadlock, 1984; Hadlock *et al.*, 1987). Hadlock *et al* stated that the regression equation derived from white middle class population appeared to be applicable to the population of different socioeconomic and racial characterstics[10] and Ruvolo *et al* also supported the same (Ruvolo, 1987). But a number of studies have come up advocating the need of population specific nomograms for appropriate obstetric care (Salomon, 2006; Zaidi *et al.*, 2009).

Babuta *et al* reported the lower means of all four fetal biometric parameters in 2nd and 3rd trimesters than Western nomograms in Rajasthani population and suggested for the need of locally derived nomogram (Babuta, 2013). It is generally thought that small size of Indian neonates at birth is attributable to small maternal size and inadequate nutrient supply during late pregnancy; but early fetal growth, when nutrient requirements are very small and there are no constraints on space for growth, it should be similar to that of other populations (Yajnik *et al*., 2003; Kinare *et al*., 2010; Kanade, 2008). This suggests the need of population specific dating formulae and pre-conceptional as well as early pregnancy interventions to optimize fetal growth. Kinare *et al*. (2010) described fetal size on sonography in rural Indian population and found that sonography at 18 weeks underestimated gestational age compared with the LMP date by a median of -1.4 days.

Fetal AC and BPD were markedly smaller than the Western references at 18 weeks, whereas FL and HC were comparable. In late pregnancy (28-36 weeks), all measurements were smaller than the Western references. The deficit was greatest for BPD and AC. Hence, fetal biometric parameters were reported significantly smaller than the western references after 22 weeks gestation and variation increased as pregnancy progressed and GA tends to be underestimated and IUGR is diagnosed frequently (≥30%) (Kinare *et al*., 2010; Singh, 2012). Accurate assessment of GA by sonography can be of great importance in management decisions during pregnancy. This study presents dating formulae based on sonographically derived measurements of fetal BPD, HC, AC and FL growth from a specified North Indian population. GA derived from a reliable, population specific growth curves can improve obstetric management. Our findings need to be replicated in other Indian populations with data collected for other fetal biometric parameters.

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