

Gestational Age Estimation by Ultrasonographic Measurements of Fetal Head Circumference in Local Population, Karnataka, India

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ABSTRACT

Background: Fetal head circumference (HC) is an important and most reliable individual parameter, which can be used not only for determining fetal age, but also fetal growth and the type of growth restriction- symmetrical or asymmetrical. **Objectives:** 1) To establish a reference table for fetal head circumference in normal pregnant women from 20 to 38 weeks of gestation from Belagavi District, Karnataka, India 2) To find out the predictive accuracy of gestational age determined by fetal head circumference with gestational age determined by Last menstrual period (LMP) method. **Methods:** The data was collected by using predesigned pretested questionnaire from September 2016 to January 2018. Total 768 singleton pregnant women with minimum 30 cases for each gestational week from 20 to 38 weeks of gestation, fulfilling inclusion and exclusion criteria were studied. **Statistical Analysis:** The data was analyzed using Statistical Package for Social Sciences (SPSS) version 20. Percentages, Mean, Standard Deviation and range, standard error, percentiles and regression equation etc. were performed for head circumference for each gestational week. **Results:** The regression equation derived was $GA = - 0.254 + (1.130 \times HC \text{ in cm})$. By this regression equation, the accuracy in prediction of gestational age by head circumference measurement was ranging from 99.27% at 23 weeks to 92.64% at 38 weeks of gestation. The observed difference in mean HC values in present study and that of Hadlock's was 0.09 cm at 20 weeks of gestation which went on increasing with advancing gestational age- 0.69 cm, 1.36 cm, 1.62 cm and 2.09 cm at 30, 35, 36 and 38 weeks of gestation respectively, which was statistically significant. **Conclusion:** The present study findings confirmed that the fetal head circumference measurements significantly vary among different population groups due to genetic, racial, and ethnic factors. So generation of population specific reference tables and regression equations for various fetal biometric parameters by a large scale study at national level is required for more precise reporting of gestational age and Expected date of delivery (EDD) by ultrasonography.

Keywords: Fetal head circumference, Gestational age, Ultrasonographic measurements.

INTRODUCTION

Ultrasonographic fetal biometry is the most widespread method used to establish gestational age, estimate fetal size and monitor its growth. Many curves and reference tables for fetal biometry have been published in the literature, using mean values for the bi-parietal diameter, head circumference, abdominal circumference, and femur length, which allow estimation of the fetal weight.^[1,2] An accurate knowledge of gestational age (GA) i.e. age of an unborn baby is the key for successful obstetric care. Uncertain gestational age

has been associated with adverse pregnancy outcomes including low birth weight, spontaneous preterm delivery and perinatal mortality, independent of maternal characteristic.^[3]

Fetal head circumference is an important parameter, which can be used not only for determining fetal age, but also fetal growth and the type of growth restriction- symmetrical or asymmetrical. Prenatal compression of fetal skull in fetal mal presentations, multiple pregnancies or in uterine abnormalities is common.^[4] The fetal frontooccipital head circumference is an integral component of neonatal indices of maturity and it is a more useful index of fetal maturity in cases in which variations in head shape (e.g. dolichocephaly, brachycephaly) adversely affect the accuracy of the biparietal diameter (BPD) in predicting fetal age.^[5] In symmetric intrauterine growth restriction (IUGR), fetal head size will frequently be compromised early in pregnancy and

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when dates are known unequivocally, head circumference below the third percentile for age is cause for a concern. In symmetric IUGR, the growth of fetal head is typically normal until very late in pregnancy.^[4]

It is well known that ethnicity has a significant influence on fetal biometry.^[6,7] Many variables affect fetal growth including physiological and pathological changes, such as maternal height and weight, drug or tobacco exposure, fetal sex, ethnicity, genetic syndromes, congenital anomalies and placental failure. Many charts and tables for assessing gestational age have been established. Willocks et al,^[8] in 1964 published their paper on fetal cephalometry and several standard charts have been fed into ultrasound machines for ready reference.^[9,10] A study by Lim et al,^[11] in 2000 showed a significant difference in growth of Indian as compared to Non-Indian (Malay and Chinese) fetuses. Prashant Acharya et al,^[12] concluded that if western parameters are applied to all, IUGR will be over diagnosed and correct dating will be wrong for other patients. Various other studies have determined that our fetal measurements are smaller than Caucasian fetal measurements.^[4,12-16] Use of charts derived from a different population may lead to errors in diagnosis of gestational age and over-diagnosis of intrauterine growth restriction, over or under estimation of gestational age and expected date of delivery.^[17] Hence, each particular population or ethnic group should have their own reference tables for the different fetal anthropometrical variables in order to provide the most accurate fetal assessment.

Therefore, the present study was designed to determine the relationship between fetal head circumference (HC) and gestational age with + 2 SD and to form a reference table for HC and to find out the predictive accuracy of gestational age determined by head circumference (HC) with gestational age determined by LMP method in normal pregnant women from 20 weeks to 38 weeks of gestation from Belagavi District, Karnataka, India.

Aims and objectives

1. To establish a reference table for fetal head circumference in normal pregnant women from 20 to 38 weeks of gestation from Belagavi District, Karnataka.
2. To find out the predictive accuracy of gestational age determined by fetal head circumference with gestational age determined by LMP method.

MATERIALS AND METHODS

A random case series study was done from September 2016 to January 2018. 768 pregnant women with minimum 30 cases for each gestational week from 20 to 38 weeks of pregnancy referred to the Department of Radiology, Belagavi

Institute of Medical Sciences (BIMS), Belagavi by antenatal clinic of Department of Obstetrics and Gynaecology (OBG) for routine antenatal scanning were studied after clearance from Institutional Ethics Committee. Antenatal cases with knowledge about exact date of last menstrual period (LMP) with regular menstrual cycles of 26-33 days^[18] for at least 3 cycles before conception, with delivery of a live baby with birth weight more than or equal to 2500 grams, fundal height corresponding to duration of pregnancy as per obstetricians finding, who delivered within one week of the expected date of delivery (EDD) and who delivered a newborn baby without any congenital abnormality were included in the study for analysis. Exclusion criteria were - pregnant women with age below 18 and above 35 years, with height below 140 cm, history of drug abuse, tobacco / gutkha use before and during pregnancy, oral contraceptive pills for 3 months prior to conception, and previous baby with low birth weight. women with Diabetes mellitus, hypertension detected during examination or developing later during pregnancy, women with multiple gestations, oligohydromnios, polyhydromnios, intrauterine growth retardation, or intrauterine death, women with uterine abnormalities like fibroids, bi-cornuate uterus, etc.

Method Of Collection Of Data

A predesigned, pretested, structured proforma was used for each subject separately. On entry, the ultrasonographic examination of each pregnant woman fulfilling inclusion criteria, was done after submission of completely filled 'Form F' in compliance to Pre-Conceptional and Pre-Natal Diagnostic Techniques (PCPNDT) Act, duly signed by the women undergoing ultrasonography and the radiologist conducting ultrasonography. Using standard methodology, fetal Head Circumference (HC) was measured from the leading edge of the echo from proximal skull surface to the leading edge of the echo from distal skull surface – outer to inner diameter. The reading of only first examination of each patient was included for the study purposes, although some patients underwent multiple ultrasonographic examinations during their pregnancy period.

Later around expected date of delivery, the patients or close relatives were contacted for information about delivery like date of delivery, onset of labor (spontaneous or induced), mode of delivery (vaginal or caesarean section or assisted one), place of delivery, birth weight of the baby, any congenital anomaly detected in newborn baby, etc. The ultrasound examination was done by a single radiologist on one ultrasound machine - iU22 Philips make real-time machine with 3.5 MHz electronic curvilinear transducer.

Sample Size Calculation

A sample size of 15 – 18 cases for each gestational week from 20 to 38 weeks was calculated by using the following formula. $n = (Z^2 \times S^2) / d^2$ where, n = required sample size, Z= value for α error (99%) = Z value, S = Standard Deviation from reference studies^[4,19], d = Clinically expected variation (5% of mean value).

Adjusted sample size of 26 for each gestational week was calculated by considering around 30% exclusion of cases for various reasons mentioned in inclusion and exclusion criteria. Of the total 1037 cases initially included for the study, 269 cases were excluded after their follow up till delivery for various reasons as mentioned above in inclusion

and exclusion criteria. Thus, finally present study included 768 cases for data analysis.

Statistical Analysis

The data was analyzed using MS Excel and Statistical Package for Social Sciences (SPSS) version 20. The basic categorical variables were reported as frequencies and percentages. The correlation of head circumference with gestational age was plotted using scatter plots. The descriptive statistics (mean, standard deviation and range, standard error, percentiles and regression equation) were performed for head circumference for each gestational week.

RESULTS

Table 1: Socio-demographic profile of study cases

Sr No	Particulars	Total Cases N = 768 (%)	Mean + SD
1	Age (18-35 years) < 20 21 to 25 26 to 30 31 to 35	143 (18.62) 451 (58.72) 151 (19.66) 23 (02.99)	23.59 + 3.28 years
2	Height (cm) 141 - 145 146 – 150 151 – 155 156 – 160 > 160	36 (04.69) 337 (43.88) 332 (43.23) 58 (07.55) 05 (00.65)	151.13 + 3.43 cm
3	Education Status Illiterate Primary School Secondary School Higher Secondary School Graduate & Above	42 (05.47) 131 (17.06) 412 (53.65) 154 (20.05) 29 (03.78)	9.14 + 3.14
4	Parity 0 1 2 >2	330 (42.97) 325 (42.32) 96 (12.50) 17 (2.21)	0.74 + 0.77
5	Birth weight of Newborn (grams) 2500 – 2700 2800 – 3000 3100 – 3300 > 3300	483 (62.89) 247 (32.16) 29 (03.78) 09 (01.17)	2712.22 + 181.66 gm

Of the total 768 cases included in the study between 20 to 38 weeks of gestation, the average age of the study subjects was 23.59 + 3.28 years ranging from 18 to 35 years. The mean height observed was 151.13 + 3.43 cm. Majority of the subjects (53.65%) were educated up to secondary school, followed by higher secondary school (20.05%) with average education status of 9.14 + 3.14 standard. 42 subjects (5.47%) were illiterates. Almost all (99.61%) were housewives/home makers and around 2/3rd cases were from rural

areas. 42.97% cases were primigravidae and 427 (55.60%) were from below poverty line family. Majority (79.30%) of the cases delivered in a government health institutes and 89.19% cases delivered normally. 47.79% newborns were females and 62.89% newborns were weighing between 2500 to 2700 gms with average birth weight of 2712.22 + 181.66 gms.

The average gestational age observed in the present study with reference to head circumference measurements is as shown in [Table 2].

Table 2: Average gestational age with reference to HC measurements (16.5 to 33.9 cm)

HC in Cm	No of Cases	Average Gestational Age + SD	HC in Cm	No of Cases	Average Gestational Age + SD
16.5 - 16.9	05	20.08 + 0.08	25.5 - 25.9	32	28.29 + 0.91
17.0 - 17.4	17	20.71+ 0.64	26.0 - 26.4	23	28.79 + 0.89
17.5 - 17.9	29	20.85 + 0.60	26.5 - 26.9	21	29.47 + 0.89
18.0 - 18.4	20	21.34 + 0.64	27.0 - 27.4	33	29.85 + 1.13
18.5 - 18.9	15	21.80 + 0.82	27.5 - 27.9	27	30.76 + 1.03
19.0 - 19.4	15	22.58 + 0.84	28.0 - 28.4	27	31.50 + 1.08
19.5 - 19.9	17	22.61 + 0.99	28.5 - 28.9	45	32.60 + 1.51
20.0 - 20.4	16	23.29 + 0.78	29.0 - 29.4	36	32.87 + 1.47
20.5 - 20.9	16	23.36 + 0.66	29.5 - 29.9	31	34.30 + 2.07
21.0 - 20.4	10	24.34 + 0.74	30.0 - 30.4	25	35.34 + 1.68
21.5 - 21.9	19	24.59 + 1.11	30.5 - 30.9	25	35.49 + 1.41
22.0 - 22.4	19	25.08 + 0.88	31.0 - 31.4	36	36.15 + 1.62
22.5 - 22.9	24	25.28 + 0.83	31.5 - 31.9	33	36.74 + 1.45
23.0 - 23.4	23	26.02 + 1.01	32.0 - 32.4	29	37.29 + 1.22
23.5 - 23.9	26	26.19 + 0.89	32.5 - 32.9	11	37.55 + 0.85
24.0- 24.4	15	27.05 + 1.12	33.0 - 33.4	04	37.75 + 1.16
24.0 - 24.9	19	27.59 + 0.82	33.5 - 33.9	02	38.50 + 0.10
25.0 - 25.4	23	27.66 + 0.92	Total Cases	768	

Table 3: Descriptive statistics of HC measurements (cm) for each GA (20-38 weeks)

Gestational Age (weeks)	Average GA by LMP (weeks)	HC (cm) Mean + SD	Min.	Max.	Std Error	95% Confidence Interval for Mean	
						Lower	Upper
20	20.38	17.59 + 0.50	16.7	18.6	0.08	17.43	17.75
21	21.43	18.22 + 0.71	17.2	19.7	0.11	17.99	18.44
22	22.43	19.54 + 0.90	17.4	21.9	0.15	19.22	19.85
23	23.40	20.77 + 1.21	18.4	23.4	0.19	20.37	21.18
24	24.37	21.46 + 1.16	19.2	23.7	0.19	21.05	21.86
25	25.32	22.92 + 1.04	21.1	25.5	0.15	22.61	23.23
26	26.38	23.29 + 0.83	21.5	25.5	0.13	23.03	23.54
27	27.44	25.01 + 0.87	23.2	27.0	0.13	24.76	25.27
28	28.36	25.61 + 0.94	23.0	27.4	0.13	25.34	25.87
29	29.39	26.53 + 0.69	25.1	27.9	0.10	26.32	26.74
30	30.43	27.75 + 0.76	26.4	29.8	0.11	27.53	27.96
31	31.37	28.42 + 0.66	26.9	29.6	0.10	28.21	28.62
32	32.40	29.15 + 0.83	27.9	31.6	0.14	28.86	29.43
33	33.43	29.16 + 0.89	27.0	31.3	0.14	28.88	29.45
34	34.43	30.17 + 1.06	28.4	32.2	0.17	29.82	30.52
35	35.41	30.84 + 0.87	29.0	33.2	0.14	30.56	31.12
36	36.45	31.17 + 1.10	28.6	33.3	0.18	30.79	31.54
37	37.49	31.71 + 0.81	29.6	33	0.13	31.46	31.99
38	38.44	31.73 + 0.99	29.8	33.2	0.15	31.39	31.99

Table 4: Accuracy in prediction of GA with HC measurements by regression equation

GA (wks)	No of Cases N= 768	Average GA by LMP (weeks)	Predicted GA with HC by Linear Regression Equation	Accuracy (%) in Prediction of GA with HC measurements
20	40	20.38	19.64	96.37
21	42	21.43	20.35	94.96
22	34	22.43	21.84	97.37
23	37	23.40	23.23	99.27
24	34	24.37	24.01	98.52
25	45	25.32	25.66	98.66
26	43	26.38	26.08	98.86
27	47	27.44	28.02	97.89
28	51	28.36	28.69	98.84
29	44	29.39	29.74	98.81
30	50	30.43	31.12	97.73
31	41	31.37	31.87	98.41
32	35	32.40	32.69	99.10
33	40	33.43	32.71	97.85
34	37	34.43	33.85	98.32
35	39	35.41	34.61	97.74
36	36	36.45	34.98	95.97
37	36	37.49	35.59	94.93
38	37	38.44	35.61	92.64

The gestational week wise descriptive statistics of head circumference measurements like minimum and maximum values, standard error and 95% confidence interval for mean is as shown in [Table 3].

[Figure 1] shows the graph of 5th, 50th and 95th percentile values of fetal head circumference values according to gestational week.

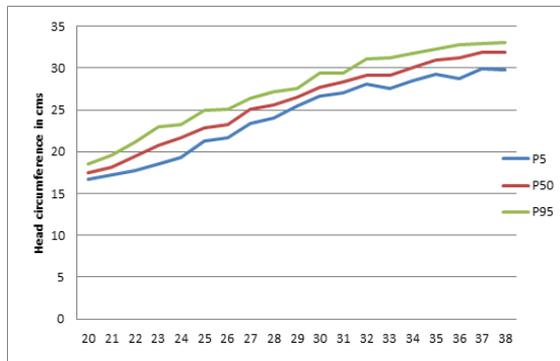


Figure 1: Graph showing the percentile values of HC measurements

The accuracy in predicting the gestational age by fetal head circumference measurements by regression equation is shown in Table 4. The regression equation derived was $GA = - 0.254 + (1.130 \times HC \text{ in cm})$, where correlation coefficient 'r' = 0.968 (highly correlated) and proportion of

variation in dependent variable (GA) $R^2 = 0.938$. By this regression equation, the accuracy in prediction of gestational age by head circumference measurement was ranging from 92.64% at 38 weeks to 99.27% at 23 weeks.

[Figure 2] shows box plot of the mean, first quartile, third quartile and extreme measurements of head circumference for each gestational week from 20 to 38 weeks of gestation by LMP in study subjects.

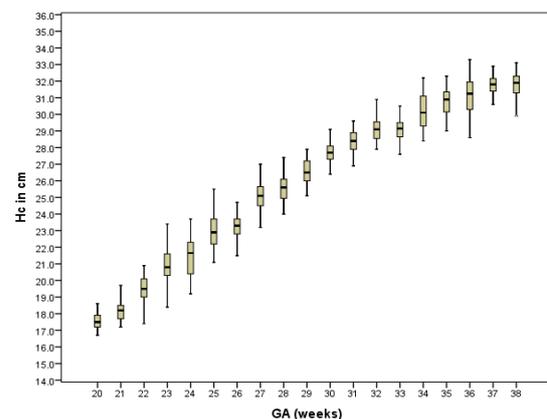


Figure 2: Box plot of HC measurements with gestational age

Table 5: Comparison of mean of HC measurements of present study with other study findings

GA by LMP	Present Study	Hadlock's ^[20]	Acharya ^[12]	Usha Jeswar ^[4]	Sumit Babuta ^[17]	Pakistan ^[19]
20	17.59	17.68	17.7	17.63	16.34	18.28
21	18.22	18.92	18.9	18.65	17.85	18.93
22	19.54	20.13	20.1	19.94	18.36	20.75
23	20.77	21.30	21.2	21.15	20.25	21.20
24	21.46	22.44	22.3	22.13	21.89	22.87
25	22.92	23.54	23.5	23.60	22.71	23.95
26	23.29	24.60	24.6	24.60	23.56	25.22
27	25.01	25.62	25.5	25.60	24.41	25.69
28	25.61	26.61	26.5	26.50	25.29	26.92
29	26.53	27.55	27.4	27.48	26.22	27.46
30	27.75	28.44	28.2	28.70	27.29	28.56
31	28.42	29.29	29.0	29.60	27.94	29.23
32	29.15	30.09	29.8	30.50	29.09	29.94
33	29.16	30.84	30.4	31.28	29.70	30.43
34	30.17	31.55	31.0	31.67	29.96	31.35
35	30.84	32.20	31.5	32.15	31.04	32.71
36	31.17	32.79	31.9	32.74	31.05	32.52
37	31.71	33.33	32.2	33.12	31.95	31.94
38	31.73	33.82	32.4	33.25	32.21	32.70

DISCUSSION

Accurate gestational age estimation is one of the most important functions of antenatal ultrasonography. Different studies have shown that fetal head circumference measurement is one of the reliable and valid parameter for fetal age estimation,^[4,5,17,20] As seen in [Table 5], there was difference in mean values of head circumference in present study and that of the other study findings.

In comparison with values of present study and Hadlock's and other study values, the observed difference was more with advancing gestational age. In local area, the reference values for assessment of gestational age and fetal well-being are reported by following the measurements by Hadlock et al, but however, there are more chances of over-diagnosis of intra-uterine growth retardation and wrong prediction of expected date of delivery especially at advancing gestational age. The head circumference value at 25 weeks in this

study was 22.92 cm while that in other studies it was found to be 23.54 cm,^[20] 23.5 cm,^[12] 23.6 cm,^[4] 22.71 cm,^[17] 23.95 cm,^[19] and at 37 weeks it was 31.71 cm in the present study, while in other similar studies, it was 33.33 cm,^[20] 32.2 cm,^[12] 33.12 cm,^[4] 31.95 cm,^[17] 31.94 cm,^[19] etc.

Hence, we need to have reference tables prepared on our local population for accurate and reliable estimation of gestational age and for determination of fetal head growth and also for accurate diagnosis of overall fetal growth and well-being.

CONCLUSION

Fetal head circumference is one of the most accurate and important parameter for estimation of gestational age. The present study findings confirmed that the fetal head circumference measurements significantly vary among different population groups due to genetic, racial, and ethnic factors. Thus, there is strong possibility of overestimation or underestimation of gestational age and EDD when the fetal biometry parametric measurements of one population is used for other racial or ethnic groups. So generation of population specific reference tables and regression equations for various fetal biometric parameters by a large scale study at national level is required for more precise reporting of gestational age and EDD by ultrasonography. Further, much more widespread studies on a larger study population are recommended to support the findings of the present study.

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