A retrospective study on the need of deriving ultrasonographical fetal gestational nomograms for fetal biometric parameters in the population of Udaipur Region

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SUMMARY

Fetal gestational age is routinely calculated in sonography by the radiologists, with the dimensions of fetal biometric parameters, as the expectant mother may not remember the exact date of the last menstrual period. The expected date of delivery is then calculated accordingly and the antenatal period is managed consequently. Accurate fetal age estimation is of crucial importance for proper antenatal care in order to reduce infant mortality, and achieve the goal of delivering a healthy child. Various studies have been done to derive fetal nomograms for indigenous populations claiming that the Western data being used cannot be applied to their population. Therefore, need of deriving ultrasonographic fetal gestational nomograms for fetal biometric parameters (head circumference, abdominal circumference and femur length) for the population of Udaipur in the northwestern region of India was investigated. Fetal sonography records of pregnant women in second and third trimesters were studied. The study derived fetal gestational nomograms for fetal head circumference, fetal abdominal circumference and fetal femur length for estimating the fetal age. These nomograms were compared with the standard nomograms of Hadlock et al. used by radiologists for the same parameters. No significant difference was found between the two, and it was concluded that the routinely used nomograms may be also used for the local population of Udaipur, Rajasthan, India.

Key words: Fetal Age – Gestational Ages – Nomogram – Chronologic fetal maturity – Biometry

INTRODUCTION

Gestational age (GA) refers to the length of pregnancy after the first day of the last menstrual period (LMP). The precise estimation of gestational age is the key for successful antepartum care and for judicious explanation of antenatal tests and successful planning of appropriate intervention

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or treatment. The expected date of delivery is an important means for the doctor, who is responsible for the safe delivery of the child. Failure of accurate gestational age assessment can result in iatrogenic prematurity or post-maturity, both of which are associated with increased perinatal mortality and morbidity (Konje et al., 2002).

Estimation of gestational age on the basis of the LMP is most reliable and is universally followed. Yet LMP cannot be used for all patients because 10-40% of all patients seen in the antenatal clinics have no knowledge of their LMPs.

Nowadays, high-resolution ultrasound imaging makes assessment of fetal biometry at early stages of pregnancy. Ultrasound gives more objective evidence of gestational age (Otto et al., 1991). Ultrasonography is preferred over other methods, because it is noninvasive, with no radiation exposure (Nyborg et al., 2002), less expensive, usually available and safe for both mother and child. The ultrasound has been used for the examination and evaluation of high-risk pregnancies and for the diagnosis of congenital malformations (Al-Bayyari et al., 2010).

Many existing references for fetal biometric measurements have been reported by a number of investigators with results that show the uniqueness to their setting. The fetal biometric charts used in Udaipur are set from a different geographical setting, race and nutritional status. No data are available for estimation of fetal gestational age for the population of pregnant women of Udaipur. It was therefore important to conduct a study to investigate the reliability of the presently used Hadlock references for the local population of Udaipur, India. The results of this study may help in creating a baseline data on estimation of the fetal gestational age in pregnant women in the region of Udaipur.

MATERIALS AND METHODS

This retrospective, descriptive, cross-sectional study was carried out on the subjects from the Udaipur region, after obtaining ethical clearance from the institutional ethical committee of Geetanjali University (GU/UEC/EC/2014/686). Fetal biometric (Abdominal Circumference, Head Circumference, Femur Length) sonography records of pregnant women who registered for antenatal care (ANC) in Geetanjali Medical College and Hospital and Rabindranath Tagore Medical College and Hospital, Udaipur, India, were taken (as this study was a record-based retrospective study, informed consent of pregnant women could not be taken**)**. Their dates of last menstrual period (LMP) were also recorded. Records of second and third trimesters were included in the study. Care was taken to include only singleton pregnancies having regular menstrual cycles and known LMP. Records of anomalous fetuses and maternal diseases – diabetes mellitus and hypertension – were excluded from the study. Total sample size was 1212 with 659 records for the second trimester (13-28 weeks) and 553 for the third trimester (29-40 weeks). the identities of the pregnant women were not revealed.

In each of the record collected, HC, AC and FL determined by sonography were noted along with gestational age of the fetus based on the last menstrual period (LMP). Gestational age determined by fetal biometric measurements were also noted. A mean of the three parameters was then calculated and plotted for each gestational age in weeks for the second and third trimesters.

Standard nomograms by Hadlock et al. currently used for measuring fetal biometric parameters were taken from text to compare with the gestational age derived by LMP (Callen, 2007).

SPSS package was utilized for statistical analysis in this study.

The mean of all three parameters was calculated (Tables 1, 2 and 3). A comparison of the means of the parameters of the present study with standard fetal growth charts inthe second and third trimesters was done (Figs. 1, 2 and 3). Regression equations for determination of gestational age from each of the fetal parameters was calculated using SPSS. A gestational age nomogram was plotted for each parameter and in each of these the nomogram, based on the table by Hadlock et al. (Callen, 2007), was also plotted. An attempt was made to see whether these plots were in agreement with each other.

Table 1. Mean gestational age (GA) (weeks) determined from ultrasonographic measurements of fetal head circumference (HC) from 100 to 400 mm HC corresponding to 14.43 to 33.14 weeks gestational age.

HC (mm)	GA Mean weeks	HC (mm)	GA Mean weeks	HC (mm)	GA Mean weeks	HC (mm)	GA Mean weeks	HC (mm)	GA Mean weeks
100	14.43	**155**	18.28	**210**	22.85	**265**	28.55	**320**	35.72
105	14.86	**160**	18.64	**215**	23.32	**270**	29.13	**325**	36.42
110	15.14	**165**	19.37	**220**	23.76	**275**	29.71	**330**	37.11
115	15.43	**170**	19.44	**225**	24.28	**280**	30.37	**335**	37.95
120	15.82	**175**	19.84	**230**	24.91	**285**	30.91	**340**	38.59
125	16.17	**180**	20.17	**235**	25.33	**290**	31.7	**345**	39.53
130	16.45	**185**	21.21	**240**	25.91	**295**	32.13	**350**	40.28
135	16.84	**190**	21.12	**245**	26.34	**300**	32.5	**390**	31.28
140	17.14	**195**	21.39	**250**	26.86	**305**	33.63	**400**	33.14
145	17.52	**200**	21.98	**255**	27.41	**310**	34.26		
150	17.92	**205**	22.4	**260**	27.64	**315**	34.99		

Table 2. Mean gestational age (GA) (weeks) determined from ultrasonographic measurements of fetal abdominal circumference (AC) from 85 to 400 mm AC corresponding to 14.71 to 34.71 weeks GA.

AC (mm)	GA Mean weeks	AC (mm)	GA Mean weeks	AC (mm)	GA Mean weeks	AC (mm)	GA Mean weeks	AC (mm)	GA Mean weeks
85	14.71	**145**	19.57	**205**	24.86	**265**	30.35	**325**	36.06
90	15.09	**150**	20.04	**210**	25.37	**270**	30.92	**330**	36.65
95	15.5	**155**	20.48	**215**	25.81	**275**	31.48	**335**	37.13
100	15.81	**160**	20.94	**220**	26.2	**280**	31.94	**340**	37.7
105	16.26	**165**	21.33	**225**	26.69	**285**	32.31	**345**	38.14
110	16.61	**170**	21.83	**230**	27.15	**290**	32.81	**350**	38.57
115	17.11	**175**	22.19	**235**	27.19	**295**	33.29	**355**	39.09
120	17.47	**180**	22.68	**240**	28.05	**300**	33.86	**360**	39.43
125	17.92	**185**	23.15	**245**	28.47	**305**	34.28	**400**	34.71
130	18.65	**190**	23.56	**250**	29.01	**310**	34.71		
135	18.75	**195**	23.99	**255**	29.44	**315**	35.18		
140	19.16	**200**	24.39	**260**	30.08	**320**	35.63		

Table 3. Mean gestational age (GA) (weeks) determined from ultrasonographic measurements of femur length (FL) from 13 to 79 mm corresponding to 13.79 to 40 weeks GA (last reading of 89mm may be due to technical error).

FL (mm)	GA Mean weeks	FL (mm)	GA Mean weeks	FL (mm)	GA Mean weeks	FL (mm)	GA Mean weeks	FL (mm)	GA Mean weeks
13	13.79	**28**	18.41	**42**	23.47	**56**	29.11	**70**	35.7
15	14.29	**29**	18.75	**43**	23.93	**57**	29.76	**71**	36.15
16	14.5	**30**	19.14	**44**	24.33	**58**	30.14	**72**	36.62
17	15	**31**	19.47	**45**	24.67	**59**	30.62	**73**	37.11
18	15.14	**32**	19.8	**46**	25.12	**60**	30.96	**74**	37.66
19	15.61	**33**	20.16	**47**	25.49	**61**	31.41	**75**	38.12
20	15.84	**34**	20.53	**48**	25.87	**62**	31.91	**76**	38.64
21	16.15	**35**	20.89	**49**	26.2	**63**	32.4	**79**	40
22	16.4	**36**	21.27	**50**	26.77	**64**	32.83	**89**	27.57
23	16.74	**37**	21.57	**51**	27.14	**65**	33.36		
24	17.11	**38**	21.96	**52**	28.1	**66**	33.76		
25	17.41	**39**	22.36	**53**	27.92	**67**	34.2		
26	17.78	**40**	22.96	**54**	28.42	**68**	34.71		
27	18.1	**41**	23.15	**55**	28.83	**69**	35.21		

Figure 1

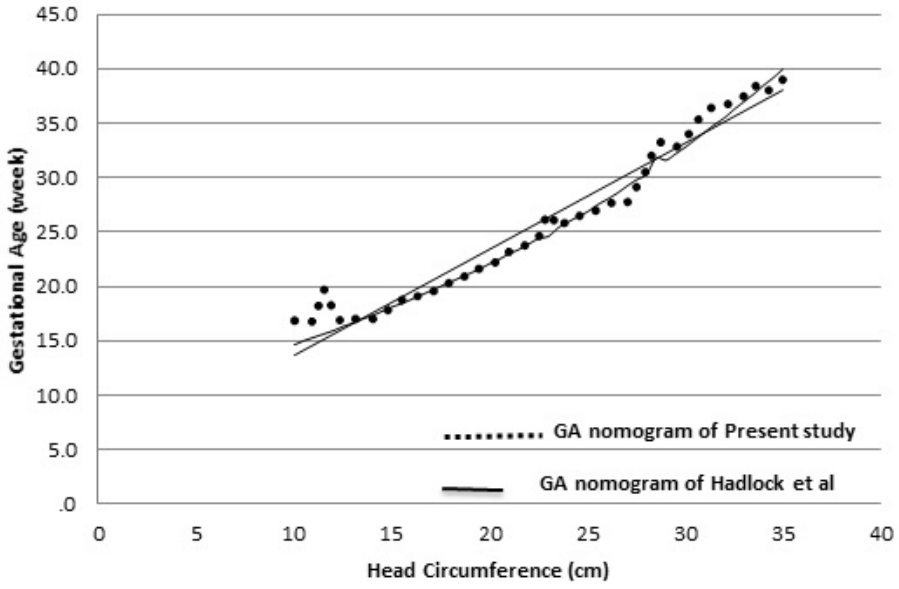

Fig. 1.- Gestational age nomograms derived from ultrasonographic Head Circumference measurements of present study vs that of Hadlock et al. (1982).

Further, Student's t test was used to evaluate statistical consonance of the present data with the table by Hadlock et al.

The correlation coefficient between gestational age by LMP method and by the three parameters (HC, AC, FL) using USG was calculated to determine a negative or positive relationship between the nomograms of the present study and that of currently used nomograms for various fetal biometric parameters.

ANOVA test was done to study the statistical difference of means for all the parameters, namely HC, AC and FL.

Figure 2

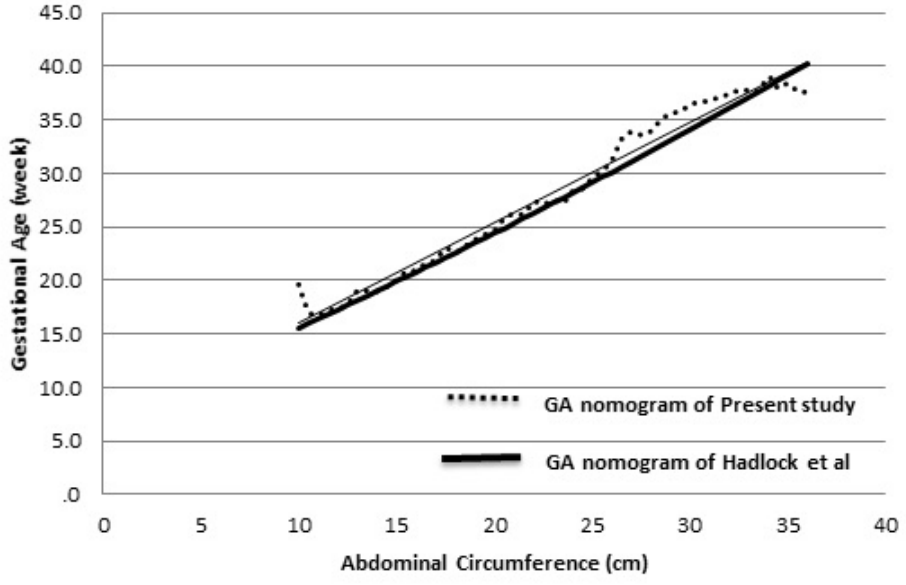

Fig. 2.- Gestational age nomograms derived from ultrasonographic Abdominal circumference measurements of present study vs that of Hadlock et al. (1982).

Figure 3

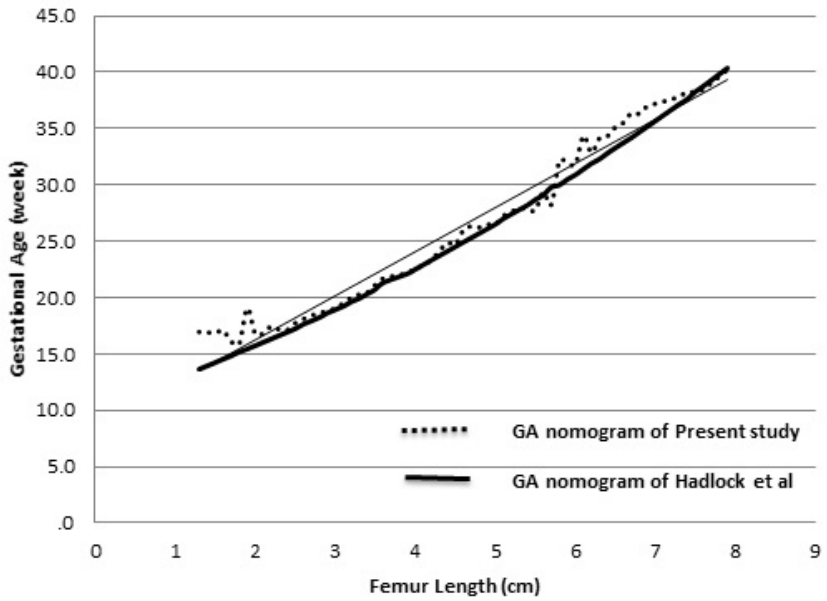

Fig. 3.- Gestational age nomograms derived from ultrasonographic Femur Length measurements of present study vs that of Hadlock et al. (1982).

In the present study, the average full-term baby's mean head circumference is 32.2 cm, with a standard deviation of 0.59 cm as compared to 33-38 cm given in text. The mean abdominal circumference in this study is 31.76 cm with a standard deviation of 0.2 cm as compared to 30.5-36.5 cm (Avery et al., 2000). The mean femur length at term (42 weeks) was found to be 70.5 cm, with a standard deviation of 0.13 cm as compared to 76-79 mm.

In this study, the mean gestational age by USG at term (42 weeks by LMP) was found to be 32.7 weeks, with a standard deviation of 5.8 weeks. The mean gestational age by USG at 28 weeks (LMP) was 27.29 weeks, with a standard deviation of just 1.31 weeks. It shows that the gestational age obtained in the second trimester was more accurate if compared to that obtained in the third trimester.

RESULTS

The mean head circumference, the abdominal circumference and the femur length were obtained for each gestational week determined by LMP. At full term, the mean head circumference was of 32.2 cm (±5.9 cm), the abdominal circumference was of 31.76 cm (±2 cm), the femur length was of 70.5 cm (±1.3 cm) (Tables 1-3).

The regression equation calculated in the present study for determination of gestational age from the head circumference is y = 0.973x + 3.958, where y = Gestational Age (weeks), x = head circumference (cm). The correlation coefficient r = 0.98, which means a strong positive relationship between the curves of the present study and that of the currently used nomogram for HC (Fig. 1).

The regression equation in the current study for the determination of gestational age from the abdominal circumference is y = 0.941x + 6.531, where y = Gestational Age (weeks), x = abdominal circumference (cm). The correlation coefficient r = 1, which means a strong positive relationship between the curves of the present study and that of the currently used nomogram for AC (Fig. 2).

The regression equation calculated in the present study for the determination of gestational age from the femur length is y = 0.973x + 3.958, where y = Gestational Age (weeks), x = femur length (cm). The correlation coefficient r = 1, which means a strong positive relationship between the curves of the present study and that of the currently used nomogram for FL (Fig. 3).

The gestational age determined by various ultrasonographic measurements of fetal biometric parameters (HC, AC, FL) was not significantly

different from that derived from LMP (P > 0.05). Student's t test showed that the difference in gestational age determined by combining all the readings of all the fetal biometric parameters by USG and gestational age determined by the LMP method in the second trimester was not significant (P = 0.39).

DISCUSSION

Available literature

It is an established fact that fetal age can be determined by the regression equations available for various fetal biometric parameters like HC, AC, FL and biparietal diameter. Different studies have found that there is a need for developing regression equations for fetal age determination of different geographical and ethnic regions (Konje et al., 2002; Al-Bayyari et al., 2010; Acharya et al., 2009; Varol et al., 2001; Snijders, 1994). The availability of such data for the population of Udaipur is scarce, and therefore this study was conducted to ascertain whether the Western data for fetal age determination by measuring fetal biometric parameters could be utilized for the local population of Udaipur.

Review of literature

According to a study on Indian women, until the end of the thrirty-fourth 34 week the growth parameters are quite same for the BPD, HC and FL, but then these parameters start lagging behind until the fortieth week (Acharya et al., 2009). However, in this study, the abdominal circumference was found to differ significantly after 30 weeks as compared to our study, where the difference was not found to be significant. In another study, significant correlations exist between BPD, AC, FL and estimated GA based upon correct last menstrual history (Varol et al., 2001). A study on the population of Africa also showed no significant ethnic differences between mothers in fetal biometry at the second trimester. They support the recommendation that ultrasound in practical healthcare can be used to assess gestational age in various populations with little risk of error due to ethnic variation (Salpou, 2008). A study of fetal biometry between weeks 14 and 40 of gestation showed that, despite methodological differences between the various studies, the meanfifth and ninety-fifth centiles were essentially the same (Snijders et al., 1994). Another previous study of fetal ultrasound biometry on Puerto Rican population, by De la Vega, showed similar fetal growth patterns as those reported from mixed US populations (De La Vega et al., 2008).

However, some studies by previous researchers have shown contrasting results. A study on a population of Jaipur, Rajasthan, India saw that sonography at 18 weeks underestimated gestational age compared with the LMP date by a median of -1.4 days (Babuta et al., 2013). Another study shows that the growth of rural Indian fetuses differs from the Western sonographic references that are generally used in clinical practice in India (Kinare, 2010). In the present study, the data consists of a mixed rural and urban population, and its sonographic references are not significantly different from the Western ones.

Inference of statistical analysis of present study

Comparison of gestational age nomogram derived from the measurements of head circumference by Hadlock et al. (1982) with our study revealed no significant difference (P value 0.36 for the second trimester and 0.28 for the third trimester). Comparison of gestational age nomogram derived from the measurements of the abdominal circumference by Hadlock et al. (1982) with our study showed no significant difference (P value 0.31 for ^{the} second trimester and 0.17 for ^{the} third trimester). Comparison of gestational age curve derived from the measurements of the femur length by Hadlock et al. (1982) with our study also showed no significant difference (P value 0.24 for the second trimester and 0.16 for the third trimester).

ANOVA test was applied and the F value was calculated to be 9.584167421, which is more than the critical value. This concludes that the difference in gestational age determined by various fetal parameters and LMP method is not significant. Thus, the present study recommends the use of conventionally used tables for determination of the gestational age of the fetus.

However, regression tables for more accurate gestational age determination for the local Indian population of pregnant women of Udaipur region have been constructed.

Impact of the present study

Regression equations for estimation of fetal age by USG measurements of fetal biometric parameters – HC, AC, FL – are now made available and can be utilized for the local population of the Udaipur region. Yet the study confirms that the previously used standard Western data is applicable to the local Indian population of Udaipur also.

CONCLUSION

Thus, to sum up, fetal age determination by sonography measurement of AC, HC and FL with utilization of already available Western nomograms was found to be applicable to a subset of the northwestern region of India, namely Udaipur.

Strengths of the study - The results of the current study are generalizable to the population of Udaipur region, reliable and versatile.

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