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Original article

Assessment of fetal gestational age in different trimesters from ultrasonographic measurements of various fetal biometric parameters

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KEYWORDS

Gestational age, Obstetric ultrasonography, Biparietal diameter, Head circumference, Abdominal circumference, Femur length.

ABSTRACT

Introduction: Fetal biometry is a methodology devoted to measuring several parts of fetal anatomy and their growth. *Aim*: The present study was carried out to assess gestational age in the second and third trimesters with the help of ultrasonographic measurements of four fetal biometric parameters (i.e., biparietal diameter [BPD], head circumference [HC], abdominal circumference [AC], and femur length [FL]) in the local population (Jaipur Zone) of Rajasthan, and also to evaluate efficacy and significance of these four fetal biometric parameters in the prediction of gestational age by ultrasound. *Materials and methods*: Three hundred and thirty cases of normal pregnant females were studied (165 – second trimester [13–28 weeks] and 165 – third trimester [29–40 weeks]) with the known last menstrual period (LMP) and studied once during gestation. *Results*: Biparietal diameter and head circumference were found to be equally best predictors of gestational age and to determine the expected date of delivery (EDD) in the second trimester and BPD and FL in the third trimester. Abdominal circumference was the least accurate parameter in both trimesters. Variability in predicting gestational age (using all four parameters) was ±2 weeks in the second trimester and +2 to −4 weeks in the third trimester. The accuracy decreased and variability increased as the pregnancy advanced from the second to third trimester. Mean measurements of fetal biometric parameters were found lower than Western monograms in each week of both trimesters. *Conclusions*: Variation in predicted gestational age by ultrasonography (USG) is attributed to the anthropometric difference between the two populations due to racial, genetic, nutritional, and socioeconomic factors. Therefore, population-specific measurements should be made to generate tables and regression equations for more precise reporting of gestational age and EDD by USG.

1. Introduction

Gestational age is the age of an unborn baby.[1] The accurate knowledge of gestational age is the key for successful antepartum care and critical interpretation of antenatal tests and successful planning of appropriate intervention or treatment. In past, gestational age has been established by a combination of the historical information and physical examination. Predictions were based on menstrual history, maternal sensations of fetal movements, assessment of uterine size by bimanual examination in the first trimester, initial detection of fetal heart tones by Doppler, and uterine fundal height measurement.[2–7]

However, it has been reported that even in the best known cases, the menstrual history index and fundal height measurement techniques were also fraught with error.[8] Timed ovulation and in vitro fertilization with known date of conception are expected to estimate the gestational age

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accurately. Unfortunately, the last menstrual period (LMP) cannot be used for all patients because 10–40% of all patients seen in the antenatal clinics have no knowledge of their LMPs or a history of irregular menstrual cycles or have been on oral contraceptives within 2 months of their LMPs.[7,9] Determining gestational age from the palpated dimensions of the uterus may be affected by uterine fibroids and maternal body habitus. Therefore, in most pregnancies the date of ovulation or conception cannot be accurately predicted as outlined by other methods and hence gestational age must be estimated by other methods.

Sonographic measurements of the fetus provide information about fetal age and growth. They are used to assign gestational age, EDD, estimated fetal weight, and diagnose growth disturbances. Fetal biometry is a method devoted to the measurement of several parts of fetal anatomy and their growth.[10] The real-time ultrasound scanners have given a number of ultrasonic biometric parameters to determine gestational age. The most commonly used fetal biometric parameters are crown-rump length, fetal biparietal diameters (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) to determine gestational age, fetal weight, and growth in different trimesters. In the absence of known date of LMP or where fundal height does not agree with dates, these parameters are valuable in estimating the gestational age of the fetus.

Standard fetal growth charts and tables as given by the previous workers of obstetric ultrasound evaluate whether the dimensions of a particular parameter are normal for that age. Since fetal growth is very rapid, fetal growth parameters change significantly with gestational age and must be evaluated against normal tables or graphs. The prenatal measurement of fetal parameters and estimated size and weight vary among different populations, depending upon their racial demographic characteristics and nutrition. Biometric curves for one population may overestimate or underestimate the fetal age when used for another population with different demographic characteristics. Unfortunately, the obstetrical tables used in our country are produced from the data collected in the population of developed countries which may vary from our population.

Therefore, the present study was undertaken to assess gestational age in the second and third trimesters with the help of sonographic measurements of four fetal biometric parameters (i.e., BPD, HC, AC, and FL) in the local population (Jaipur zone) of Rajasthan and to compare these values with Western normograms. The study also aimed to find out the predictive accuracy of gestational age determined by ultrasonography (USG) with menstrual age determined by the LMP method in local population.

2. Materials and methods

A study was conducted on observations collected from 330 normal pregnant females between 13 weeks and 40 weeks of gestation referred from the antenatal clinics of the Department of Obstetric and Gynecology to the Department of Radio Diagnosis at Mahila Chikhitsalya and in association with the Department of Anatomy at Sawai Man Singh Medical College and Hospital, Jaipur (Rajasthan) with effect from March 2010 to August 2011 (18 months).

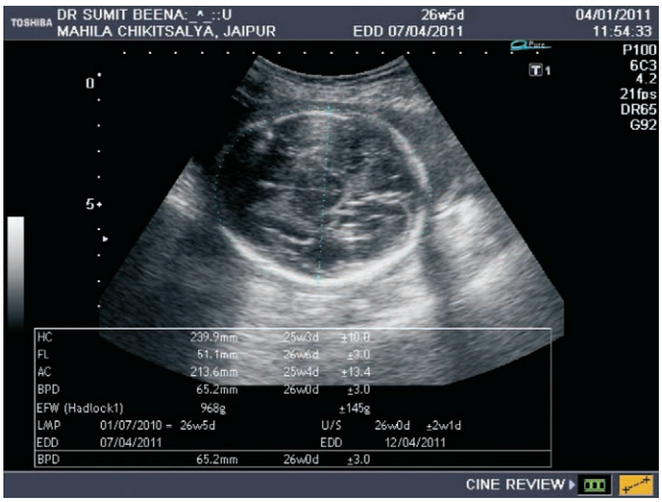
Three hundred and thirty cases (165 – second trimester (13–28 weeks) and 165 – third trimester [29–40 weeks]) with the known date of LMP were studied. All fetuses were examined once during gestation. Only patients with history of regular menses and known date of LMP with the absence of any known maternal disorder which can affect normal fetal growth were included. Also multiple pregnancies and congenital anomalies of fetus encountered during USG were excluded. Only singleton and viable pregnancies were included for the study purpose. The age group included ranged from 18 years to 40 years and parity ranged from 1 to 4. The present study has been approved by the Institutional Research Review Board.

2.1 *Data acquisition*

All examinations were performed by using a gray-scale real-time machine (Toshiba color Doppler Nemio XG) employing a 6–3 MHz convex transducer (S. No. [E_2DO 816111], Version 3.5.000). Other materials used were Aqua saline jelly, multiformate camera, single-coated sonographic films, TVS Probe (PVM-651VT) frequency (8–5 MHz).

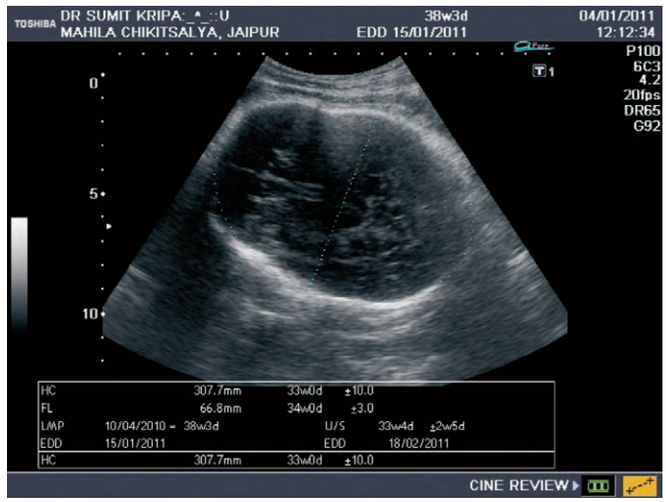
A completely filled form-F (in compliance to PCPNDT Act) duly signed by the radiologist conducting sonography and the women undergoing sonography was submitted prior to examination. Each sonography was done after a complete antenatal checkup by obstetrician and maternal laboratory investigations such as complete blood count, venereal disease research laboratory (VDRL) test blood urea and sugar, urine routine, and microscopic. Personal record, detailed obstetrical, and menstrual history was obtained. If no anomaly was seen in fetus during sonography, then the following four fetal biometric parameters were measured in different planes to assess gestational age (Fig. 1):

1. Biparietal diameter (Fig. 1a): The fetal head was imaged in an axial section with the fetus in a direct occiput transverse position. The instrument was set at medium gain so that parietal bones measure approximately 3 mm in thickness. The BPD was measured from the outer surface of the skull table to the inner margin of the opposite skull table.
2. Head circumference (Fig. 1b): The fetal HC was traced along the outer perimeter of the calvarium using the electronic digitizer at the same level as for the BPD.
3. Abdominal circumference (Fig. 1c): It was measured on the transverse image of the fetus at the level of liver. A major landmark was the umbilical portion of left portal vein deep in the liver; fetal stomach represented the second landmark. The measurements were made from the outer edge of one side to the outer edge of other side.
4. Femur length (Fig. 1d): It is usually easy to see fetal long bones from 13 weeks onward. The measurement was obtained with a linear array transducer. It was measured along the long axis of diaphysis using a straight line from the tip of greater trochanter to lateral epicondyle.



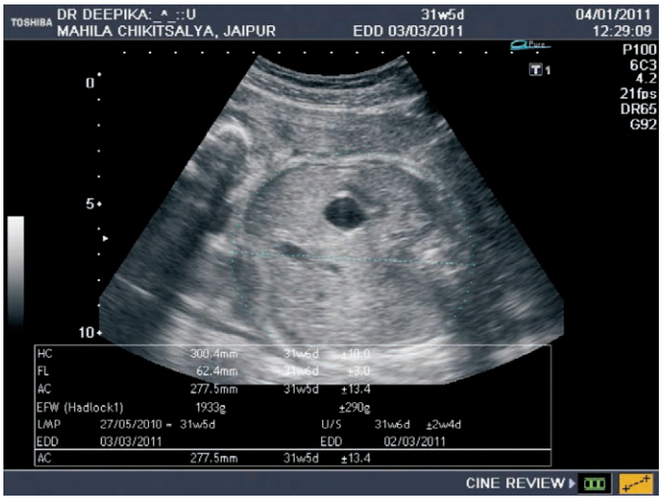
BPD: 65.2 mm 26w0d ± 3.0

Fig. 1(a) – Method for measuring biparietal diameter (BPD).



HC: 307.7 mm 33w0d ± 10.0

Fig. 1(b) – Method for measuring head circumference (HC).



AC: 277.5 mm 31w5d ± 13.4

Fig. 1(c) – Method for measuring abdominal circumference (AC).

FL: 65.4 mm 33w2d ± 3.0

Fig. 1(d) – Method for measuring femur length (FL).

The gestational age and expected date of delivery (EDD) were calculated by the traditional LMP method by adding 9 calendar months and 7 days to the first day of the last normal menstrual period. Thereafter, predictive gestation age was recorded with respect to each parameter and mean gestational age calculated. Each parameter was measured in mm and gestational age in weeks, and their mean was calculated. These means were then compared with published Western normograms (Hadlock's) for each parameter.[8,11–18] Ideal parameters for the second and third trimesters to assess gestational age were found from the observations obtained. The observations collected were used to compare gestational age given by USG with gestational age calculated by the traditional LMP method. The R value and p value of gestational age, BPD, HC, AC, and FL were calculated to find statistical significance and correlation.

3. Results

Cross-sectional data with descriptive statistical values of the present study are presented in Tables 1–4.

Observations of Tables 1 and 2 show that the BPD (53%) is the most accurate individual parameter, followed by HC (42%) and FL (40%), with AC being the least accurate individual parameter to determine gestational age in the second trimester. In the third trimester, BPD (32%) and FL (31%) were equally accurate individual parameters followed by AC (20%) and HC (19%) to determine gestational age. Tables 1 and 2 also show that the accuracy of each parameter decreases from the second to third trimester. The observations show that the mean gestational age is the most accurate in predicting gestational age in both trimesters. Ninety-three percent accuracy is found equally in the second and third trimesters. Also, varia-

tions in gestational age by all four parameters increase from ±2 weeks to −4 weeks from the second to third trimester.

Tables 3 and 4 show the comparison of four fetal biometric parameters of present study with Hadlock's findings[8] (Western normograms) according to gestational age (LMP) in the second and third trimesters, respectively. In the second trimester, the % difference varies from +7.14% to −5.3% for BPD, from −0.95% to −9.15% for HC, from +0.92% to −9.12% for AC, and from −5.43% to −13.64% for FL. In the third trimester, the % difference varies from −2.29% to −6.67% for BPD, from −1.46% to −5.34% for HC, from −5.15% to −11.24% for AC, and from −2.91% to −6.57% for FL.

The overall trend in both trimesters (in every respective week) shows that the mean measurement of all four parameters in the present study was lower than Western normograms.

Table 1 – Difference in gestational age in the second trimester.

Difference in GA (in weeks)	BPD		Head circumference		Abdominal circumference		Femur length		Mean GA	
	No.	%	No.	%	No.	%	No.	%	No.	%
+2	1	0.61	1	0.61	10	6.06	6	3.64	0	00
+1	17	10.30	9	5.45	63	38.18	72	43.64	0	00
0	88	53.33	69	41.82	55	33.33	66	40.00	153	92.72
−1	46	27.88	56	33.94	33	20.00	18	10.91	7	4.24
−2	13	7.88	27	16.36	2	1.21	1	0.61	3	1.81
−3	0	0.00	3	1.82	2	1.21	2	1.21	2	1.21
−4	0	0.00	0	0.00	0	00	0	00	0	0.00
Total	165	100.00	165	100.00	165	100.00	165	100.00	165	100.00

GA: Gestational age; BPD: Biparietal diameter.

Table 2 – Difference in gestational age in the third trimester.

Difference in GA (in weeks)	BPD		Head circumference		Abdominal circumference		Femur length		Mean GA	
	No.	%	No.	%	No.	%	No.	%	No.	%
+2	1	0.61	4	2.42	5	3.03	1	0.61	5	3.03
+1	3	1.82	8	4.85	14	8.48	3	1.82	1	0.60
0	53	32.12	32	19.39	33	20.00	51	30.91	153	92.72
−1	28	16.97	22	13.33	42	25.45	13	7.88	3	1.81
−2	31	18.79	40	24.24	32	19.39	49	29.70	1	0.60
−3	31	18.79	37	22.42	32	19.39	30	18.18	1	0.60
−4	18	10.91	22	13.33	7	4.24	18	10.91	1	0.60
Total	165	100.00	165	100.00	165	100.00	165	100.00	165	100.00

GA: Gestational age; BPD: Biparietal diameter.

Table 3 – Comparison of mean of parameters of present study with Hadlock's finding according to gestational age (last menstrual period) in the second trimester.

GA according to LMP (in weeks)	Biparietal diameter			Head circumference			Abdominal circumference			Femur length		
	Present study (in mm)	Hadlock (in mm)	% difference	Present study (in mm)	Hadlock (in mm)	% difference	Present study (in mm)	Hadlock (in mm)	% difference	Present study (in mm)	Hadlock (in mm)	% difference
13	22.50	21	7.14	74.50	82	−9.15	60.50	60	0.83	9.50	11	−13.64
14	25.25	25	1.00	91.50	97	−5.67	73.63	73	0.86	12.38	14	−11.57
15	28.09	29	−3.14	105.18	111	−5.24	81.36	86	−5.40	15.18	17	−10.71
16	32.36	32	1.13	122.82	124	−0.95	99.91	99	0.92	18.73	20	−6.35
17	36.00	36	−0.00	129.00	138	−6.52	106.50	112	−4.91	21.90	24	−8.75
18	37.87	39	−2.90	141.93	151	−6.01	119.00	125	−4.80	24.80	27	−8.15
19	40.73	43	−5.28	154.18	164	−5.99	130.82	137	−4.51	27.55	30	−8.17
20	44.10	46	−4.13	163.40	177	−7.68	143.10	150	−4.60	30.20	33	−8.48
21	47.90	50	−4.20	178.50	189	−5.56	150.70	162	−6.98	33.10	35	−5.43
22	50.19	53	−5.30	183.63	201	−8.64	158.13	174	−9.12	35.13	38	−7.55
23	55.06	56	−1.68	202.50	213	−4.93	174.19	185	−5.84	38.31	41	−6.56
24	58.25	59	−1.27	218.88	224	−2.29	185.75	197	−5.71	41.50	44	−5.68
25	61.38	62	−1.00	227.13	235	−3.35	193.88	208	−6.79	43.63	46	−5.15
26	63.50	65	−2.31	235.58	246	−4.24	206.00	219	−5.94	45.42	49	−7.31
27	66.00	68	−2.94	244.10	256	−4.65	212.00	230	−7.83	47.70	51	−6.47
28	67.86	71	−4.42	252.86	266	−4.94	225.29	240	−6.13	49.86	54	−7.67

GA: Gestational age; LMP: Last menstrual period.

Table 4 – Comparison of mean of parameters of present study with Hadlock's finding according to gestational age (last menstrual period) in the third trimester.

GA according to LMP (in weeks)	Biparietal diameter			Head circumference			Abdominal circumference			Femur length		
	Present study (in mm)	Hadlock (in mm)	% difference	Present study (in mm)	Hadlock (in mm)	% difference	Present study (in mm)	Hadlock (in mm)	% difference	Present study (in mm)	Hadlock (in mm)	% difference
29	70.60	73	23.29	262.20	275	24.65	222.80	251	211.24	52.40	56	26.43
30	73.93	76	22.72	272.93	284	23.90	239.93	261	28.07	54.79	58	25.53
31	75.71	78	22.94	279.36	293	24.66	253.64	271	26.41	57.50	60	24.17
32	77.33	81	24.53	290.87	301	23.37	266.53	281	25.15	60.40	62	22.58
33	81.10	83	22.29	297.00	304	22.30	274.43	291	25.69	62.14	64	22.91
34	82.08	85	23.44	299.50	308	22.76	280.92	300	26.36	63.08	66	24.42
35	84.20	87	23.22	310.40	315	21.46	288.20	309	26.73	65.85	68	23.16
36	84.88	89	24.63	310.47	328	25.34	290.88	318	28.53	66.59	70	24.87
37	87.07	90	23.26	319.50	333	24.05	296.50	327	29.33	68.14	72	25.36
38	85.86	92	26.67	322.14	338	24.69	305.57	336	29.06	69.14	74	26.57
39	88.17	93	25.19	327.06	342	24.37	313.67	344	28.82	71.78	75	24.29
40	89.75	94	24.52	330.38	346	24.51	321.13	353	29.03	72.00	77	26.49

GA: Gestational age; LMP: Last menstrual period.

4. Discussion

Many researchers in the past worked on the correct estimation of gestational age by measuring different biometric parameters by ultrasound. By using four parameters to determine gestational age in the present study, we found that the accuracy of each parameter decreases as pregnancy advances. Observations show that the mean gestational age is the most accurate in predicting gestational age in both trimesters. Ninety-three percent accuracy is found equally in the second and third trimesters.

These findings were supported by Hadlock et al.[8,18] They stated that a combination of multiple fetal parameters (BPD, HC, AC, and FL) provided age estimates that were significantly better ($P = 0.05$) than using any single parameter alone. There was a significant reduction in the overall reliability and maximum observed error when multiple fetal parameters were used instead of a single parameter.[8,18] Also Hohler found that the measurement of more than one fetal parameter, in a sense, prevents over-reliance on any single measurement which by itself might mislead the clinician.[19] Thus, it appears that the estimate using the mean fetal gestation period is both accurate and precise than a single measurement.[19]

Hadlock et al stated that the regression equations developed from white middle class population appeared to be applicable to the populations of different socioeconomic and racial characteristics.[18] Ruvolo et al found no statistically significant difference in FL vs gestational age in a racially mixed population of Blacks, Asians, and Caucasians.[20] However, the sample size for each group was small and the chart used was not specified.[20] Our findings suggest that the means of all four fetal biometric parameters in both trimesters (in every respective week) was lower than Western normograms.

Yeo et al conducted a study on Chinese, Malaysian, and Indian population which showed that fetal FL are apparently shorter than the Indian FL, therefore proving the existence of differences in ultrasound measurements of FL in different ethnic groups.[21] Lai and Yeo demonstrated slightly smaller BPD, HC, AC, and FL – more pronounced over the course of gestation in Asians compared with white fetuses.[22]

Lachman and Shen conducted a study on 128 cases of Chinese fetuses and found a statistically significant difference in fetal FL between Chinese population and established FL normograms and the Chinese FL was shorter by 0.56 mm which was ultrasonically manifested as a 0.3 week difference in gestational age estimation.[23] Thomas et al demonstrated that the use of growth curves that do not take race and gender into consideration may lead to inaccurate diagnosis of infants as small (SGA) or large (LGA) for gestational age.[24]

Various studies have determined that Indian fetal measurements are smaller than the Caucasian fetal measurements.[25–30] Madan et al conducted a study on 1539 infants of different races as white, Asian Indian, Chinese, Hispanic, other Asian, and others at Northern California.[25] They stated that Asian (Chinese, Asian Indian, or other Asian), Hispanic, and other babies had lower mean birth weights, shorter mean lengths, and smaller mean HC than white babies. Asian, Hispanic, and other male babies were lighter, shorter, and had smaller heads than white male babies. They concluded that failure to account for ethnic differences in intrauterine growth may lead to inaccurate diagnosis of fetal growth abnormalities in infants of Asian ancestry.[25]

Shipp et al found a significant difference in the mean variance from the expected FL and BPD among the fetuses of women in the second trimester with respect to racial group.[26] Less-than-expected FL were noted among the fetuses of Asian mothers, and more-than-expected FL were noted among the fetuses of black mothers, compared with the femurs of fetuses of white mothers.[26] Jeswar et al did a cross-sectional study to determine gestational age by fetal HC with its two standard deviations in 200 gravid patients on North Indian

population.[27] They found discrepancy of 1.09–2.39 between HC at term in Caucasian and Indian population.[27]

Kinare et al described fetal size on sonography in rural Indian population and compared it with those in European and urban Indian populations.[28] The results showed 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 weeks and 36 weeks), all measurements were smaller than the European references. The deficit was the greatest for AC and BPD.[28]

Anatomic dimensions of fetus vary according to the race, nutritional status, build, and geographic location of the origin of the parents. As the growth trend of our fetuses is slower than Western fetuses, all fetal biometric parameters predict imprecise gestational age and fetal weight, more so as pregnancy advances. We still do not have our own population-specific tables for the determination of gestational age of our own population. Therefore, if we use Western normograms for gestational age determination, there are chances of significant error in gestational age estimation and the fetus may appear small for date even when it is not.

Strengths of the study were that it was population-based and sonographic data were collected from a representative sample of study population. Measurements were made according to standardized protocols by a single experienced medical sonologist, ensuring high-quality measurements and minimizing 'noise' due to interobserver variation. Our study suggests the need for construction and use of fetal biometric normograms that are specific for individual population and ethnic group to determine gestational age and EDD to enable the development of better clinical guidelines for Indian populations.

5. Conclusion

The present study reveals the use of multiple fetal biometric parameters (BPD, HC, AC, and FL) to predict the most accurate gestational age and determine EDD in the population of Rajasthan. Our analysis confirmed that fetal anthropometric measurements significantly differ among different population groups due to racial, genetic, and ethnic factors. Thus, biometric curves of one population may overestimate or underestimate gestational age and EDD when used for other racial or ethnic groups. Hence, a large-scale study at national level in other Indian population is required to generate population-specific tables and regression equations for more precise reporting of gestational age and EDD by sonography on the basis of various fetal biometric parameters. Further studies are recommended to support the above-mentioned finding.

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