GESTATIONAL AGE PREDICTION FROM ULTRASONOGRAPHIC FETAL PARAMETERS IN A TURKISH POPULATION

A. Demircan, M.D.** / Y. Berkol, M.D.*

* *Associate Professor and Chairman, Service of Gynecology and Obstetrics, II, Okmeydanı Social Security Hospital, İstanbul, Turkey.*
** *Instructor Department of Gynecology and Obstetrics, Faculty of Medicine, Marmara University, İstanbul, Turkey.*

SUMMARY

In this longitudinal study, fetal biparietal diameters (BPD), femur length (FL), abdominal circumference (AC), head circumference (HC), mean head diameters (MHD), mean abdominal diameters (MAD), humerus length (HL), and biocular diameters (BOD) were measured ultrasonographically between 14-41 weeks' gestation in 30 normal fetuses. By using multiple regression analyses, gestational age prediction curves were constructed for each parameter and evaluated in regard to other data. The comparison of our gestational age curves for BPD, AC, and HC were in good agreement with the results presented by Hadlock et al. and for FL, HL and BOD with Jeanty et al. The differences between our values and the data for MHD and MAD were great especially in the third trimester, approaching 2.6 weeks on the average. These differences in the tables may result from different population studies, genetic variations or from technical errors. It is concluded that, for the establishment of gestational age, new nomograms should be constructed for each fetal parameter, considering the differences presented in this preliminary study.

Key words: Gestational age, ultrasonographic fetal age determination, fetal parameters, gestational age charts.

INTRODUCTION

Gestational age determination from various fetal parameters by ultrasonographic means is a sound method in obstetric practice. When the dates are not known or in doubt, especially with concomittant maternal complications, the knowledge of fetal age will affect the selection of management modality. Fetal parameters correlate well with gestational age and several nomograms have been reported in the literature (1 - 5).

In this preliminary study, gestational age tables were constructed from ultrasonographic fetal parameters, compared to the others and their implications were discussed.

MATERIALS AND METHODS

This study was undertaken in the Service of Gynecology and Obstetrics, II, Okmeydanı Social Security Hospital, between October 1985 - September 1986. The study population consisted of 30 gravid patients with known regular menstrual history, who underwent 3 to 8 ultrasonographic examinations from 14 to 41 weeks' gestation. Patients with known medical and obstetric complications were excluded from the study. In each case, the pregnancy resulted in a normally developed neonate. The gestational ages of all neonates were confirmed by the pediatricians according to the Dubowitz Score (6).

To measure the biparietal diameter (BPD), femur length (FL), abdominal circumference (AC), head circumference (HC), humerus length (HL), and biocular diameter (BOD), a commercially available linear - array real - time scanner (Siemens Sonoline SL) with a 3.5 MHz frequency transducer was used, and the velocity calibration was set to 1540 m/sec. The measurements were carried out according to the techniques described before (1, 2, 7 - 13), on a freeze frame with manually controlled electronic calipers.

BPD measurements were obtained through a plane containing cavum septum pellucidum anteriorly and falx cerebri posteriorly from the outer to inner aspects of the fetal skull. Head diameters were obtained by measuring the BPD and the frontooccipital diameter on the same plane; then the circumference was calculated by using the formula for an ellipse: $C = (D_1 + D_2) \times 1.57$. For AC measurements, the umbilical - portal venous system was visualized and two perpendicular diameters were obtained and the circumference was calculated from the formula for an ellipse. Mean head diameters and abdominal diameters were calculated according to the formula: $D_1 + D_2 / 2$. FL was measured by defining both ends of the calcified portion of the shaft, excluding the femur head. For HL measurements, the transducer was rotated alongside the fetal chest until a clear image was obtained. The binocular diameters were measured in three fetal head positions: occipitoposterior, occipitotransvers, and occipitoanterior, from the lateral border of one orbit to the opposite lateral border of the other.

Multiple measurements were obtained for each parameter until three closely corresponding results were obtained within a 2 mm range and the average was taken (13). Each examination interval was centered on the week (e.g., 16 week interval = 15.51 - 16.49 weeks). The data obtained were plotted on charts and statistically analysed (McIntosh, Statview512+ system) to construct regression curves from the mean values at each weekly interval. The predicted gestational age values are presented in tables in comparison to other data.

RESULTS

The polynomial functions best describing the relation between gestational age and the fetal parameters are given in Table I. The predicted gestational age values for specific measurements of BPD, FL, AC, HC, MHD, MAD, HL, BOD are compared with the data from other studies through Tables II to VII respectively.

Gestational age derived from BPD measurements agreed well with the results of Hadlock et al (4), and the mean difference was 2.9 days (range 1 - 4 days). The mean difference between our results and that of Jeanty et al (4) was 4.5 days (range 1 - 8 days), and there were obvious differences with the results of Shepard et al (4) (range 11 - 12 days) (Table - II).

Predicted menstrual age for femur lengths gave best results in comparison to the results of Jeanty et al (4) (mean 5.4 days, range 1 - 8 days). The mean difference between our results and the data of Hadlock et al (4) was 6.4 days (range 0 - 11 days), and with the data of Hohler et al (4) it was 6.7 days (range 0 - 11 days) (Table III).

For AC, our results agreed with the data of Hadlock et al (15), the mean difference was 5.6 days (range 0 - 8 days), But there were obvious differences between our results and the results of Tamura et al (2) (maximum 23 days) (Table IV).

Our computed gestational age values for HC were well correlated with the results of Hadlock et al (16), the mean difference being 4.8 days (range 0 - 10 days). The differences were 6.5 days (range 4 - 12 days), and 5.5 days (range 1 - 10 days) for Tamura et al (2), and Jeanty et al (4) respectively (Table V).

For MHD and MAD, the major differences between our results and the data of Tamura et al (2) were about 18 days between 28 - 32 weeks, and 20 days between 33 - 40 weeks respectively (Table VI).

The mean difference between our HL values and the data of Jeanty et al (1) was 2.8 days (range 1 - 9 days); from 19 weeks onwards the differences were less than 4 days. Our BOD values also gave good correlation with the results of Jeanty et al (1), the mean difference was 1.7 days (range 0 - 3 days). With the results of Mayden et al (13) there were obvious differences between 4 - 17 days (Table VII).

DISCUSSION

Diagnostic ultrasonography is accepted as an important tool in the investigation of obstetric problems. Among its uses are determination of gestational age and establishment of the expected date of confinement (7, 17, 18), as 5 - 10 % of pregnancies are postdate and 6 % are preterm (17). Nearly all fetal parameters can be used to determine gestational age, but the most commonly used ones are BPD, FL, AC and HC; HL, BOD, MHD and MAD are used less (Table I).

BPD is one of the most important parameter in use for dating pregnancy, because it is relatively easily obtained and can be measured rapidly and reproducibly (2, 18). BPD growth rate is well correlated with gestational age and can be measured accurately as early as 12 weeks gestation (18). There is a rapid and an almost linear growth up to 28 weeks' of gestation and this allows more reliable dating (2). Between the interval of 14 to 28 weeks, the BPD predicts dates within ± 7 to 11 days, however this accuracy is lost in the third trimester and the margins increase to 3 - 4 weeks (2, 14, 18). Thus, BPD measurement between 14 th and 26 th weeks is accepted as the most reliable parameter according to many investigators (2, 19). After 30 weeks' gestation, BPD should not be used solely for dating purposes, because of wide margins. Its reliability decreases because of the changes of the head shape (dolichocephaly, brachycephaly, breech presentation), and Cephalic Index (CI) should also be measured to be in normal ranges (2, 7, 20, 21). The results of this study are in good accordance with others, especially with that of Hadlock et al (4) (Table II).

Establishing gestational age from the FL measurements are the second frequently used technique. FL growth is linear up to 26 weeks' gestation and variability is within narrow margins, but after 26 weeks of gestation it exceeds that of BPD's (2, 4, 11). O'Brien showed that, the 95 % confidence limits of a FL measurement at 14 to 20 weeks were ± 6 days, from 20 to 30 weeks were ± 12 days and from 30 to 41 weeks were ± 18 days (5), and the accuracy of this parameter in assigning gestational age is reported to be within ± 2.8 weeks regardless of the pregnancy interval used (2). The predicted gestational age from FL gave good correlation with the results of Jeanty et al (4). The greatest difference was 7 days at the most (Table III).

The AC has a relationship with gestational age similar to that of the BPD. There is a fairly linear relationship until the last weeks of pregnancy when some flattening of the growth and a widening of the standard deviation occurs (15, 22). This late flattening does not, however, appear to be as marked as BPD's (22). AC have a much higher rate of intraobserver and interobserver variability than the BPD or the FL, and a single diameter does not properly describe the size of the abdomen (2, 23). Changes in the configuration of the abdomen with breathing movements or during compression by the transducer further increase the variability (about ± 2 - 3 weeks) (23), a fact which was noted in the present study, especially in late gestation. One way of overcoming this problem is to use abdominal perimeter measurements (direct measurement) to correct the variability (23). By contrast, AC is the most useful dimension for the evaluation of fetal growth (2). The predictive accuracy of ± 5 days has been reported when the examination is made before 26 weeks (18). The comparison of gestational age predictions of this study with the results of Hadlock et al (15) gave good correlation, and the difference was 9 days at the most (Table IV).

The head circumference is considered to be less affected than the BPD in conditions that deform the fetal head. Thus, HC can be used to predict the gestational age (24), to make the diagnosis of microcephaly and can be used in the evaluation of intrauterine growth retardation (24). The comparison of gestational age showed a difference of 8 days at the most (Table V.) HC is less accurate than BPD as a predictor of fetal age prior to 26 weeks' gestation (2). It is also more difficult than either BPD or FL to measure with precision (2). Usually, over 30 weeks, some guessing is necessary when the fetal head is larger than the transducer or when reflection artifacts mask the lateral part of the skull. This guessing decreases the accuracy of the predictions based on this parameter (24). The accuracy of the HC in prediction of gestational age in the third trimester (± 2 to 3 weeks) is comparable to the accuracy of the BPD during this period (7). In a study by Hadlock, the HC measurements were within ± 1 week of the true gestational age (16). Recently, Tamura and associates (2) proposed that mean head diameters (MHD) and mean abdominal diameters (MAD) can be used for estimating gestational age (Table VI).

HL can be used for estimating gestational age when no other parameter is available or as an adjunct in doubtful cases (12). It has an almost linear growth with gestational age. In Table VII, the comparison of results gave almost similar values with Jeanty et al (1), the differences were 7 - 9 days in early pregnancy.

BOD is another adjunct for determining gestational age although it is used mostly to differentiate congenital malformations (7). There is an almost linear relationship with gestational age up to 24 weeks and a flattening can be seen afterwards (10). This parameter is especially easy to obtain where the fetus is face up simply represents the transverse distance between the lateral walls of the orbit (7). In Table VII, the comparison of our results gave identical values with Jeanty et al (1), and with the results of Mayden et al (13) the differences were great in the first and third trimesters, and near term it was almost 4 weeks' higher.

It is evident from the literature that, the BPD remains the most accurate parameter for assigning dates in the second trimester of pregnancy (1, 2). In that period, the 95 % confidence limits for BPD assigned dates are 7 - 10 days. Although FL is the next best parameter for establishing gestational age (2, 25) the confidence limits are controversial and reported to be as wide as ± 2 - 3 weeks (2). In the third trimester, BPD, FL, HC, AC, BOD, MHD, and MAD are valid. However, they are less accurate partially because of the techniques used and partially because of the greater variability of fetal size at any particular gestational age as pregnancy advances (7).

Considering the present knowledge in the literature, it seems that, assigning gestational age in utero is a complicated task which depends on the use of skill and good judgement (14). The important thing is that, the ultrasonographer should have some idea of which parameters are best at specific trimesters, and their confidence limits as well. When in doubt, other parameters should be checked for confirmation. In general, when data from several sources agree within one or two weeks range, one can be sure that the estimation is more reliable than when data are derived from one source only (2, 14, 25, 26).

At present, for assigning gestational age, we are using the nomograms presented by others. The present study clearly confirmed that there are differences between the mean values for different populations. Although our nomograms correlated well with the ones given by Jeanty et al for FL, HL, and BOD, Hadlock et al for BPD, AC and HC we can not overlook the differences presented for AC, HC, MHD, and MAD. It is concluded that, we should construct new nomograms that will describe our population better, and we hope that this preliminary study is only the beginning.

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Table I: Best fitting regression models for predicted gestational age

x / y	Polynominal equation	r^2
BPD / GA	$y = 9.32 + 0.125 (x) + 0.002 (x^2)$	0.989
FL / GA	$y = 0.415 (x) + 7.386$	0.988
HC / GA	$y = 10.871 + 0.021 (x) + 1.894 E{-4} (x^2)$	0.971
AC / GA	$y = 0.099 (x) + 5.643$	0.985
MHD / GA	$y = 10.855 + 0.068 (x) + 0.002 (x^2)$	0.971
MAD / GA	$y = 6.284 + 0.29 (x) + 1.564 E{-4} (x^2)$	0.985
HL / GA	$y = 7.479 + 0.334 (x) + 0.002 (x^2)$	0.944
BOD / GA	$y = 0.602 (x) + 1.498$	0.962

GA = Gestational age

Table II: Predicted menstrual age for biparietal diameters (BPD)

BPD (mm)	Reference (weeks + days)			
	This study	Jeanty (4)	Hadlock (4)	Shepard (4)
15	11 + 4	10 + 4	10 + 6	
20	12 + 4	11 + 6	12 + 1	
25	13 + 5	13 + 1	13 + 4	
30	14 + 6	14 + 4	15	12 + 4
35	16 + 1	15 + 6	16 + 4	14 + 1
40	17 + 4	17 + 2	18	15 + 4
45	19	18 + 5	19 + 4	17 + 2
50	20 + 4	20 + 2	21 + 1	18 + 2
55	22 + 2	21 + 6	22 + 6	20 + 5
60	24	23 + 6	24 + 4	22 + 3
65	25 + 6	25 + 2	26 + 3	24 + 2
70	27 + 6	27 + 1	28 + 2	26 + 1
75	29 + 6	29 + 1	30 + 3	28 + 1
80	32	31 + 1	32 + 4	30
85	34 + 2	33 + 3	34 + 5	32 + 1
90	36 + 5	35 + 5	37	34 + 1
95	39 + 2	38 + 2	39 + 3	36 + 2
98	40 + 5	40		

Table III: Predicted menstrual age for femur lengths (FL)

FL (mm)	Reference (weeks + days)			
	This study	Jeanty (4)	Hohler (4)	Hadlock (4)
15	13 + 4	14 + 1	13 + 4	14 + 1
20	15 + 5	15 + 6	15 + 1	15 + 5
25	17 + 5	17 + 4	16 + 6	17 + 1
30	19 + 6	19 + 3	18 + 4	18 + 6
35	21 + 6	21 + 1	20 + 4	20 + 5
40	24	23 + 1	22 + 3	22 + 4
45	26	25	24 + 4	24 + 4
50	28 + 1	27	26 + 4	26 + 4
55	30 + 1	29 + 1	28 + 5	28 + 5
60	32 + 2	31 + 1	31	30 + 6
65	34 + 2	33 + 2	33 + 2	33 + 2
70	36 + 3	35 + 4	35 + 6	35 + 5
75	38 + 4	37 + 5	38 + 2	38 + 2
80	40 + 4	40	40 + 6	40 + 6

Table IV: Predicted menstrual age for abdominal circumference (AC) values

AC (mm)	Reference (weeks + days)		
	This study	Hadlock (15)	Tamura * (2)
100	15 + 4	15 + 4	
125	18	17 + 6	17 −
150	20 + 3	20	19
175	23	22 + 2	22
200	25 + 3	24 + 4	25 −
225	28	26 + 6	26
250	30 + 2	29 + 2	28
275	32 + 6	31 + 4	29 +
300	35 + 2	34 + 1	34 −
325	37 + 5	36 + 4	35 −
350	40 + 2	39 + 2	37 −
360	41 + 2	40 + 2	38
370			40
380			41

(*, + means, weeks + 1 - 3 days, and - means, weeks - 1 - 3 days)

Table V: Predicted menstrual age for head circumference (HC) values

HC (mm)	Reference (weeks + days)			
	This study	Hadlock (16)	Jeanty (4)	Tamura * (2)
100	14 + 6	14 + 6	14 + 4	
125	16 + 3	16 + 2	16 + 2	16 −
150	18 + 2	18 + 1	18	17 +
175	20 + 3	20	19 + 6	19 +
200	22 + 4	22 + 1	22	22
225	25 + 1	24 + 3	24 + 3	24 +
250	27 + 6	27	26 + 6	26 +
275	30 + 6	29 + 6	29 + 5	29 +
300	34 + 1	32 + 6	32 + 6	33
325	37 + 5	36 + 2	32 + 6	36
340	39 + 6	38 + 4	38 + 4	40
350	41 + 1	40	40	
360		41 + 4	41 + 5	

(*, + means, weeks + 1 - 3 days, and - means, weeks - 1 - 3 days)

Table VI: Gestational age in weeks relative to the mean head diameters (MHD) and the mean abdominal diameters (MAD)

weeks + days / MHD			weeks + days / MAD	
This study	Tamura (2)	Mean diameter (mm)	This study	Tamura * (2)
18 + 3	18	47	20	20 —
19 + 1	19	50	21	21 —
20 + 3	20	55	22 + 3	22
22	21	60	24	24 —
23 + 4	23	65	25 + 4	26 —
25 + 2	25	70	27 + 1	27 —
27 + 1	26	75	28 + 4	28 —
29 + 3	28	80	30 + 3	29
31 + 3	29	87	32 + 4	31
33 + 1	31	90	33 + 3	32
34 + 6	34	94	34 + 6	34
36 + 4	35	98	36	35
37 + 3	37	100	36 + 6	36 —
39	40	103	37 + 6	36 —
40		105	38 + 3	36 —
41 + 5		108	39 + 3	37 —
		110	39 + 6	38
		115	41 + 3	40

(*, ± equals plus or minus 3 days)

Table VII: Predicted menstrual age for humerus lengths (HL) and biocular diameters (BOD)

Length (mm)	HL Reference (weeks + days)		BOD Reference (weeks + days)		
	This study	Jeanty (1)	This study	Jeanty (1)	Mayden (13)
15	12 + 6	14 + 1	10 + 4	10 + 3	12 + 1
20	15	15 + 6	13 + 3	13 + 3	14 + 1
25	17	17 + 6	16 + 4	16 + 3	16
30	19 + 2	19 + 6	19 + 3	19 + 3	18 + 3
35	21 + 5	22	22 + 4	22 + 2	21
40	24	24 + 2	25 + 4	25 + 2	23 + 2
45	26 + 5	26 + 5	28 + 4	28 + 2	26 + 2
50	29 + 1	29 + 2	31 + 4	31 + 2	30
55	31 + 6	32	34 + 4	34 + 1	35
60	34 + 5	34 + 6	37 + 4	37 + 1	40
65	37 + 4	37 + 5	40 + 4	40 + 1	
69	40	40 + 1			