Yonsei Medical Journal
Vol. 42, No. 3, pp. 299 - 303, 2001

Original Article

Evaluation of Gestational Age Based on Ultrasound Fetal Growth Measurements

Füsun Varol[1], Ahmet Saltık[2], Petek Balkanlı Kaplan[1], Tülay Kılıç[1], and Turgut Yardım[1]

Departments of [1]Obstetrics and Gynecology and [2]Public Health, Trakya University School of Medicine, Turkey.

Monitoring fetal growth and assessing its predictors have important place in antenatal care management. Accurate prediction of gestational age (GA) and birth weight (BW) is clinically important. Standard growth curve chosen should be evaluated to see if it satisfies the criteria for a valid assesment. In this paper, for the purpose of contributing to develop national standards and to evaluate Hadlock's standard data pertaining to 1411 fetuses were examined. Of 1411 normally growing fetuses, one measurement for AC, BPD and FL was taken by ultrasound. GA was assessed via menstrual history which is also confirmed by ultrasonography. Several variables, AC, BPD, FL, FL/AC, BPD/FL and dependent variables (GA & BW) were modelled mathematically. Percentile values, correlation coefficients were calculated and well functioning regression equations were produced for the fetal growth evaluation. Simple correlation model re-confirmed that AC, BPD and FL were well predictors of GA. Via modelling by multivariate regression analysis (adj. R^2=937), GA=4.945 (95% CI: 4.661- 5.654) + .606 AC + .105 BPD + .286 FL can be estimated. It couldn't be possible establishing an appropriate equation for prediction of BW vith current data. Our study is intended to draw an attention on requirement of national standards although Hadlock's standard growth curve may evaluate fetal development accurately. Forming comprehensive cohort group is under our consideration. The equation we developped (shown in the results), might be a working contribution.

Key Words: Gestational age, biparietal diameter, femur length, abdominal circumference, fetal growth prediction

INTRODUCTION

Accurate estimation of fetal age is important for appropriate antenatal management. The estimation of gestational age by ultrasound is based on the known relationship between fetal age and size.[1-3] The fetal ultrasonographic biometric data can be evaluated by referring to standard growth curves derived from large number of normally growing fetuses.[2] Current data evaluation requires several decisions to be made. The first involves choosing an appropriate standard growth curve,[2] which should be tested to determine that it satisfies the criteria for a valid growth curve. Finally, the data from the population being studied should be compared with the standard curve range of variability. Since the range of variability may be different even in similar populations, it is necessary to decide if our standard growth curve (Hadlock's growth curve) satisfies the biometrics of normally growing fetuses in the population being studied.

Received May 3, 2000
Accepted March 16, 2001
* *Presented at FIGO 2000, Washington DC, USA.*

MATERIALS AND METHODS

The data from 1411 fetuses were evaluated retrospectively during this study. Ultrasonographic evaluation was conducted by chief residents. Women with multiple gestations, diabetes, or growth disorders, such as intra-uterine growth retardation were excluded. Cross-sectional measurements of each case were used for assessing the gestational age (GA) and the birth weight (BW). Biparietal diameter (BPD) was measured in the axial plane at the level where the continuous midline echo is broken by the septum pellucidum cavum. Measurements were made from the outer to inner margins of the fetal skull. The abdominal circumference (AC) was measured directly by a plot on a transvers section through the fetal abdomen at a level where the umblical vein and

the stomach bubble were seen. The femur was measured from the origin to the distal end of the shaft. We also calculated the femur length/abdominal circumference ratio (FL/AC) and the BPD/FL ratio in the assessment of fetal growth. Since head circumference (HC) was not measured in all cases, it was not taken into consideration in this evaluation. Five *independent variables* (BPD, FL, AC and proportional parameters of FL/AC, BPD/FL) and *dependent parameters* (GA and BW) were biomathematically modelled and graphed to determine the two best fitting curves. Percentile values and Pearson correlation coefficients were also calculated, and a well-functioning multivariate regression equation was produced for estimating gestational age.

SPSS 8.0 version was utilised for statistical analysis.

RESULTS

Cross-sectional data with descriptive statistical values are presented in Tables 1 and 2.

Parity was between 0 - 4, median with 1, mode with 1 (95% CI: 0.68 - 0.77), and primigravidity was 45.4% of all cases. Percentile values for the study group, which show the data distribution, are summarized in Table 2. Ultrasound measurements were taken once in each case, and were evaluated by Correlation Analysis for GA, which was estimated on the basis of the last correct menstruation date. Results obtained are shown in Table 3.

Gestational age (week) = 4.945 (95% CI: 4.661 - 5.654) + 0.606 AC + 0.105 BPD + 0.286 FL

As shown by Table 3, significant correlations exist between BPD, AC, FL and estimated GA based upon correct last menstrual history. GA as the main dependent variable and its correlative profiles with potential predictors are represented by Figures 1, 2, and 3, with the two best fitting curves.

According to the findings of Table 3, the best working formula for GA prediction is Gestational age (week) = 4.945 (95% CI: 4.661 - 5.654) + 0.606

Table 1. Descriptive Statistics of Study Parameters (n = 1411)

Variables	Mean ± SD	CI 95%	Min, max, range
Gestational age (week)	29.4 ± 8.0	28.9 - 29.8	13 - 40; 27 week
Birth week	38.5 ± 2.3	38.3 - 38.7	15 - 40; 25 week
Birth weight (gm)	3351 ± 482	3319 - 3384	700 - 3900; 3200
AC (cm)	25.10 ± 8.1	24.67 - 25.54	3.9 - 39.4; 35.5
BPD (cm)	7.13 ± 2.12	7.02 - 7.24	1.21 - 10.50; 9.29
FL (cm)	5.80 ± 1.91	5.69 - 5.91	1.21 - 24.2; 23.0
FL / AC	.22 ± .02	.23 - .22	.06 - .33; 5.5 folds
FL / BPD	.82 ± .15	.78 - .80	.22 - 2.00; 9.0 folds
Mother age	26.7 ± 4.9	26.3 - 27.1	18 - 41; 23 year
Parity	.7 ± .8	.64 - .76	0 - 4; 4 pregnancy

Table 2. Variables and Percentile Values (n = 1411)

Variables	Percentiles								
	3	5	10	25	50	75	90	95	99
Birth weight (gm)	2300	2642	2800	3050	3400	3600	3700	3750	3900
AC (cm)	9.89	10.60	12.15	18.03	27.23	32.00	33.86	34.90	37.56
BPD (cm)	3.06	3.37	3.80	5.40	7.66	9.00	9.45	9.62	9.90
FL (cm)	2.10	2.40	3.20	4.44	6.30	7.20	7.51	7.69	8.00
FL / AC	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.28
BPD / FL	0.60	0.64	0.67	0.73	0.77	0.81	1.00	1.00	1.00

Table 3. Regression Equations of Gestational Age (GA) Prediction from Fetal Ultrasonometric Measurements (13-40 weeks, n = 1411).

Fetal Measurements, cm	Regression equation { best fitted 2 curves }	R^2 (%)
AC	GA = 5.956 + .941 AC	.914
AC	GA = 20.355 - 1.260 AC + .1006 AC^2 - 0014 AC^3	.922
BPD	GA = 2.412 + .131 BPD	.872
BPD	GA = 11.159 + $BPD^{.0131}$	.872
FL	GA = 1.863 + 6.280 FL - .211 FL^2	.908
FL	GA = 11.769 + 1.275 FL + .449 FL^2 - .020 FL^3	.927
AC, BPD	GA = 4.685 + .710 AC + .269 BPD	.932
AC, FL	GA = 5.341 + .738 AC + .272 FL	.928
BPD, FL	GA = 5.688 + .470 BPD + .505 FL	.945
AC, BPD, FL	GA = 4.945 + .606 AC + .105 BPD + .286 FL	.937

AC + 0.105 BPD + 0.286 FL using BPD, AC, and FL. Using 3 variables, we could reached an adjusted R^2 value of 93.7%, which is capable of explaining 93.7% of the entire variation in GA. Additionally, using Table 3, some improvements have been made by curve fitting efforts instead of using simple correlations.

For example, in the 2nd line of Table 3, a third order quadratic seems a better estimator of GA than a simple linear fetal AC correlation. Furthermore the exponential models are stronger than the linear models for prediction of GA based on FL. These formulas are not complicated and can be loaded into the software system of ultrasound devices and thus may interprete individual data. However, we may need to increase longitudinal

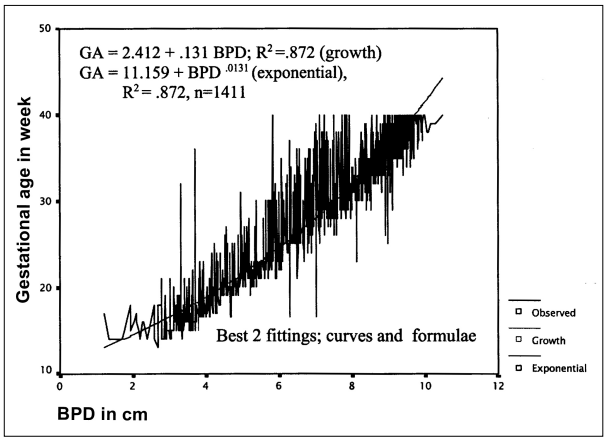

Fig. 2. Correlation between gestational age (week) and BPD measurements (cm)

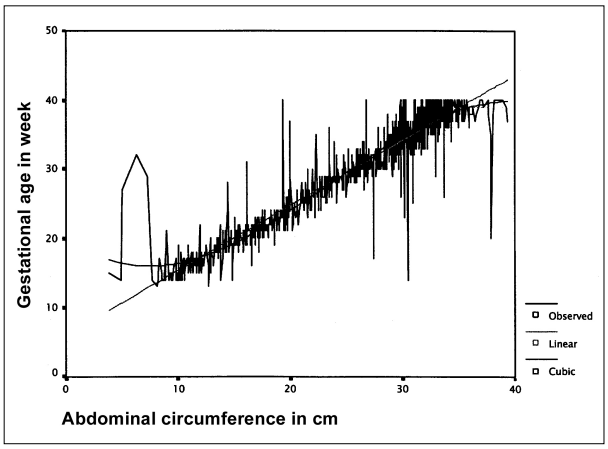

Fig. 1. Correlation between gestational age (week) and AC measurements (cm)

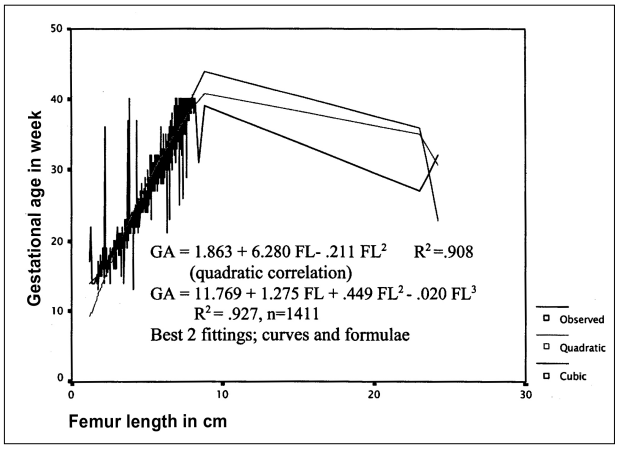

Fig. 3. Correlation between gestational age (week) and FL measurements (cm)

data sets for such interpretation. On the other hand, it is understood that, single ultrasound measurements of fetal somatic growth parameters are not good predictors of BW. This finding is in line with classical knowledge because fetal weight gain does not follow a continuously linear trend, but a declining marginal trend relative to the early pregnancy weeks and reaches a plateau during the last few weeks.

DISCUSSION

This paper presents a quantitative evaluation of prenatal growth profile. The biometric data are well defined, easily measured, reliable, and reasonably insensitive to technical errors. As more variables are measured by ultrasound, the accuracy of GA estimation increases.[4-7] The error in estimating the mean composite variables will always be less than the error for any single variable.[4] However, there is a point when the addition of further variables no longer increases the accuracy, and this point may be still undefined. Then no single variable has an advantage in terms of predictive accuracy, and the estimation of fetal age based on a single variable is no longer used in clinical practice. Furthermore, serial measurements increase the accuracy of fetal age estimation in late gestation, but fetal age determination at late pregnancy is fraught with considerable error. For example, a composite estimate of BPD, AC, HC and FL have shown a 8% improvement in predictive accuracy in early pregnancy and up to 28% improvement in late pregnancy.[8] On the other hand, unknown or uncertain menstrual data still presents a clinical dilemma, and therefore, the composite estimate of gestational age is still an area of fetal biometrics research. Our fetal biometric data can also be accurately evaluated using Hadlock's standard growth curve for the estimation of GA. So called equations may still need adjustment to allow considerations to be made for region, race, smoking and other anamnestic patient features. When growth parameters are fitted as a function of gestational age, they function well in the standard curves and its fitted curve. Careful attention is required when utilizing these standards in any given region or population. In addition to this, methodological discrepancies (Hadlock's cohort vs. our cross-sectional data) might affect this comparison.

Multi-centric, single-protocol, large scale cohort studies have best proven the validity of world-wide standard equations, curves and nomograms. These evaluations should based on two to three easily conductable measurements, such as BPD, AC, and FL, which act as strong and reliable predictors. Finally, mathematically well processed equations loaded into the software associated with ultrasound devices provide on line help and evaluation the data.

Our presentation is a local report intended to draw attention to the small variations that might affect fetal biometrical data. Gestational age calculated on the basis of last menstrual date are compatible with the estimated ages , which utilize fetal ultrasound growth parameters.

A more comprehensive cohort group is now under consideration. The equation produced for estimating GA is as follows:-

Gestational age (week) = 4.945 + 0.606 AC + 0.105 BPD + 0.286 FL

(with significant, adjusted MR^2=0.937) might be a contribution for normally growing fetuses.

Füsun Varol, M.D., Ph.D.
Trakya Üniversitesi Tıp Fakültesi,
Kadın Hastalıkları ve Doğum ABD
22030 Edirne, Turkey.
Tel: 90-284-2357641, Fax: 90-284-2357652
E-mail: feyzavarol99@usa.net

REFERENCES

1. Deter RL, Harrist RB. Assessment of normal fetal growth. In: Chervenak FA, Isaacson GC, Campbell S, editors. Ultrasound in obstetrics and gynecology. Boston/Toronto/London: Little, Brown and Company; 1993. p.361-85.
2. Deter RL. Evaluation of quantitative obstetrical ultrasound studies. In: Deter RL, Harrist RB, Birnholz JC, Hadlock FP, editors. Quantitative obstetrical ultrasonography. NewYork: Churchill Livingstone; 1986. p.15-30.
3. Hadlock FP. Gestational age determination: Third Trimester. In: Chervenak FA, Isaacson GC, Campbell S, editors. Ultrasound in obstetrics and gynecology.

Boston/Toronto/London: Little, Brown and Company; 1993. p.311-20.
4. Hadlock FP, Deter RL, Harrist RB, Park SK. Computer assisted analysis of fetal age in the third trimester using multiple fetal growth parameters. J Clin Ultrasound 1987;11:313-6.
5. Hadlock FP, Harrist RB, Shah YP, King DE, Park SK, Sharman RS. Estimating fetal age using multiple parameters: A Prospective evaluation in mixed population. Am J Obstet Gynecol 1987;156:955-7.
6. Hadlock FP, Deter RL, Harrist RB, Park SK. Fetal biparietal diameter: A critical re-evaluation of the relation to menstrual age by means of real time ultrasound. J Ultrasound Med 1982;1:97-104.
7. Hadlock FP, Deter RL, Harrist RB, Park SK. Fetal abdominal circumference as a predictor of menstrual age. AJR 1982;139:367-70.
8. Hadlock FP, Deter RL, Harrist RB, Roecker E, Park SK. A date-independent predictor of intrauterine growth retardation: Femur length/abdominal circumference ratio. Am J Radiol 1983b;141:979-84.