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Gestational Age Estimation in Late Pregnancy : A New Approach

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Summary

Knowledge of exact gestational age is very crucial to the Obstetrician. Use of ultrasound for estimating gestational age by measuring fetal characteristic like B.P.D., F.L., A.C. and H.C. is a common practice. In early pregnancy the estimates are quite accurate, but in late pregnancy (more than 30 weeks) the prediction of error is to the tune of 3 weeks. In this paper two new predictor variables, fetal kidney circumference and kidney length have been used to predict gestational age with significant reduction in the prediction error (1.5 weeks).

Introduction

Knowledge of precise gestational age is critical in the care of both high and low-risk obstetric patients. Gestational age assessment has long been the Quintessential application of ultrasonography to the practice of Obstetrics (Ott. 1985, Hadlock et al 1981, 1984). The use of multiple sonographically measured fetal characteristics has been advocated for estimation of gestational age. The fetal characteristics usually employed are biparietal diameter (B.P.D.), femur length (F.L.), head circumference (H.C.), abdominal circumference (A.C.) etc. The random error in gestational age estimation increases from about 1 week at 18 weeks gestation to almost 3 weeks after 36 weeks' gestation (Hadlock et al 1981, 1984; Ott, 1994) which at times may be responsible for caesarean sections not actually needed, increased morbidity or unnecessary use of tocolytics.

In this paper we propose the use of fetal renal measurements, kidney circumference (K.C.) and kidney length (K.L.) to estimate gestational age in late pregnancy (greater than 30 weeks of gestation), as they have a lesser prediction error and better R^2 than the dating formulae based on fetal biometric parameters like BPD, FL, HC, AC and their combinations.

Fetal kidney can be visualised as early as 12 to 14 weeks. As kidneys enlarge they become progressively easier to identify, and by 30 weeks there is sufficient fat surrounding and accentuating the normal sonolucent renal parenchyma to make identification relatively simple (Lawson, et al 1981).

Material & Methods

A retrospective study was designed to examine

the relationship between fetal kidney dimensions and gestational age. Sample was selected from the cases attending the A.N.C. Clinic of U.I.S.E. Maternity Hospital G.S.V.M. Medical College Kanpur. Criteria for inclusion in the study were as follows:

(1) The L.M.P. was exactly known and there was no history of irregular periods.
(2) The menstrual age beyond 30 weeks or more.
(3) Fetus not at the risk for congenital kidney disease.
(4) No associated medical or obstetrical complication.

Ultrasound examination was performed on Aloka SSD 620 Ultrasound Scanner with 3.5 Mhz, Trans Abdominal Convex transducer.

B.P.D., F.L., H.C., A.C., K.C., K.L., K.W., K.T. were measured in each case. Measurements were taken using the already well described landmarks & planes. Renal length was measured on the saggital view. Thickness and width of the fetal kidney were measured in a transverse fetal section. Both kidneys were visualised and the mean of the measurements of both structures was taken.

Statistical Analysis : Least squares method was used to fit the relationship between gestational age and fetal biometric parameter(s). For this purpose MINITAB package was used. The prediction equation have been compared on the basis of coefficient of determination, R^2. and root mean square deviation (RMSD) which is a combinatin of both random error and systemic error. The mathematical formula for root mean square deviation (RMSD) is 3 Average of (estimated G.A.-true G.A.)^2

Observations

The average gestational age of the sample is 34-40 weeks ± 2.61 (Table 1). Gestational age can not be measured directly. Hence we study those variables which are correlated with gestational age and try to find out a mathematical relationship between them. B.P.D. had a very high correlation coefficient with G.A. Kidney circumference & kidney length has a still higher correlation with G.A. (Table II). Table III shows that estimation of gestational age on the basis of a single parameter after 30 weeks of gestation will always be less accurate. Hadlock (1984) suggested the combination of 4 parameters B.P.D., F.L., A.C., H.C. The R^2 in this case in our study is 92.8% whereas regression of gestational age on kidney circumference and kidney length has a R^2 value of 98% (Table III). Table No. IV lists the RMSD of different regression equations. The RMSD is least in case of regression of G.A. on kidney measurements (Table IV). It is an indicator of prediction error. Along with the regression equations 95% prediction intervals were also calculated for 98 observations then the average width of prediction intervals was calculated. The prediction interval width was 1.51 weeks in case of regression of G.A. on kidney measurements which is almost half of the width of the prediction interval (3.0 weeks) when G.A. is regressed on the combination of B.P.D., F.L., A.C., H.C.

Table No. I
Showing summary values of fetal characteristics of the 98 patients

Fetal characteristic	Mean (in centimeters)	S.D.
B.P.D.	8.63	2.6
F.L.	6.65	0.47
A.C.	28.47	0.56
H.C.	31.04	1.84
K.C.	6.98	0.56
K.L.	3.91	0.42

Table No. II
Showing the correlation matrix

	G.A.	B.P.D.	F.L.	A.C.	H.C.	K.C.
B.P.D.	0.95					
F.L.	0.87	0.87				
A.C.	0.83	0.83	0.77			
H.C.	0.83	0.87	0.78	0.83		
K.C.	0.97	0.93	0.86	0.79	0.82	
K.L.	0.98	0.93	0.87	0.82	0.82	0.96

Table III
Showing results of linear regression for predicting gestational age from Fetal sonographic measurements

Fetal Measurements	Regression Equation	R^2 In%	F	p
B.P.D.	G.A.=-11.4+5.31 B.P.D. (1.42) (.16)	91.6	1041.1	<.01
F.L.	G.A. = 7.07 + 4.11 F.L. (1.53) (.23)	77.1	323.5	<01
K.C.	G.A.= 2.68 + 4.54 K.C. (.73) (.10)	95.2	1900.7	<.01
K.L.	G.A. = 10.6 + 6.10 K.L. (.47) (.12)	96.4	2540.8	<.01
B.P.D., F.L., A.C., H.C.	G.A. =-8.83 + 4.27 BPD + .778 FL + .152 AC-.101HC (1.50) (.41) (.27) (.07) (.09)	92.8	299.6	<.01
KC, KL	G.A.=6.59 + 2.00 KC + 3.55 KL (.58) (.23) (.31)	98.0	2305.6	<.01

1 Figures in parenthesis indicate the standard deviation of regression coefficients

Table No. IV
Comparison of prediction of gestational age on the basis of R.M.S.D.

Fetal characteristic(s) used as predictor variable(s)	R^2	R.M.S.D.
B.P.D.	91.6%	0.70
K.C.	95.2%	0.56
K.L.	96.4%	0.49
B.P.D., F.L., A.C., H.C.	92.8%	0.70
K.C., K.L.	98.0%	0.36

Discussion

The error in the prediction of gestational age when B.P.D. & F.L. are used as predictor variables is quite high in late pregnancy. Several other fetal characteristics and their combinations have been studied for prediction of gestational age.

Jeanty et al (1982) studied the relationship of fetal kidney measurements like kidney circumference, kidney thickness with gestational age. Alberto Chiara (1993) reported a very good correlation between right kidney length, left kidney length and gestational age (r=0.84 and 0.86 respectively). In our series we have found a correlation coefficient, r=0.98 and 0.97 between gestational age and kindey length, kidney circumference respectively (Table II). Figure I Konje et al (1997) has shown that kidney length at different gestational ages is not significantly different in small-for-date and appropriate-for-date babies. Hence fetal kidney measurements can provide a good estimate of gestational age in late pregnancy.

Figure (1) shows the scatter gram of B.P.D. with G.A. Figure (2) and Figure (3) show the Scatter gram of K.L. and K.C. with G.A. These clearly demonstrate a good linear relationship.

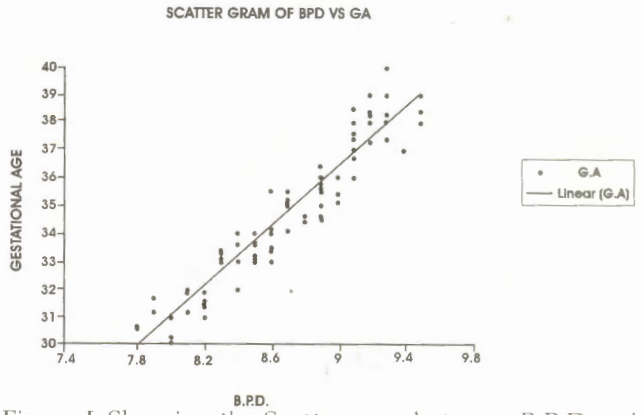

Figure I: Showing the Scattergram between B P D and Gestational Age

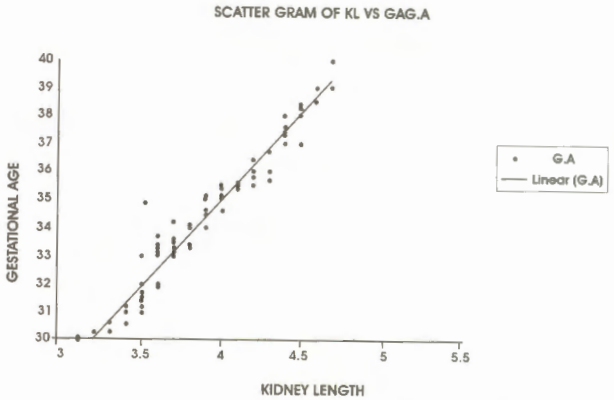

Figure 2: Showing the Scattergram between KL and Gestational Age

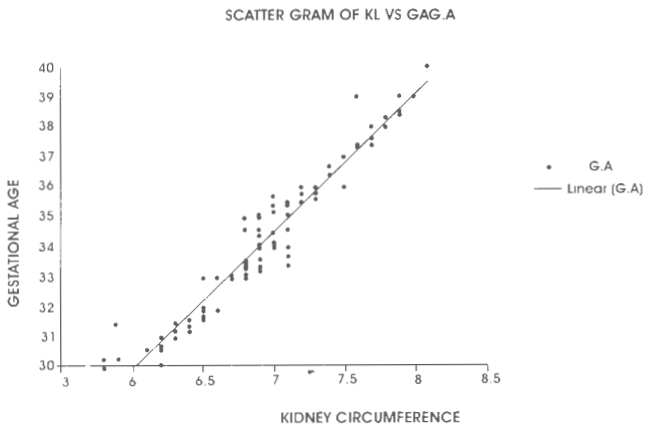

Figure 3: Showing the Scattergram between KC and Gestational Age

Table No. III lists the coefficient of determination (R^2) and various regression equations. For B.P.D. alone the R^2 is 91.6%. For a combination of B.P.D., F.L. A.C., H.C. the R^2 is 92.8%. The R^2 for a combination of K.L. and K.C. is the highest (98.0%). Our results are in agreement with Chervenak et al (1998) except for femur length found at a R^2 of 91.8%. 91.4% & 94.8% for B.P.D., F.L., and a combination of B.P.D. F.L. A.C. respectively. Hadlock et al 1984 reported a R^2 value of 98.1% for a combination of B.P.D. F.L. A.C. H.C. But his sample included cases of 11 weeks of gestational ages. This high R^2 was probably due to inclusion of early pregnancy. In our sample we have found the highest R^2 (98%) when the gestational age is regressed on a combination of kidney length & kidney circumference. Therefore this combination can provide a very accurate estimate of gestational age in late pregnancy as compared to already used fetal parameter(s).

Table IV shows root mean square deviations (R.M.S.D.). By definition, it shows how accurate is the estimate. It is minimum for a combination of K.L. and K.C. (.36).

In Table V, we have shown the prediction interval width which was computed using the MINITAB package on computer. The mean prediction interval width is up to 3 weeks when a combination of B.P.D., F.L., A.C., H.C. is used. This is reduced to half (1.5 weeks) when kidney length and kidney circumference are used to predict gestational age.

Conclusion

Prediction of gestational age in late pregnancy is very crucial for drastic obstetrical management. An error of about 3 weeks in predicting G.A. can be detrimental to the patient. In our study, we have found that fetal kidney circumference and kidney length can predict G.A. most accurately in late pregnancy (more than 30 weeks of gestation). However, this conclusion needs to be verified on a larger data set.

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Table No. V
Comparison of prediction interval width for different predictor variables

Fetal characteristic(s) used As predictor variable(s)	Prediction interval width Minimum	Maximum (in weeks)	Mean in weeks	S.D.
B.P.D.	3.18	3.23	3.20	.08
K.L.	1.98	2.01	2.00	.02
BPD, F.L., A.C., H.C.	2.95	3.07	3.00	.08
K.L., K.C.	1.49	1.57	.02	