ORIGINAL ARTICLE

Role of Fetal Kidney Length in Estimation of Gestational Age

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Abstract

Fetal Kidney Length (FKL) is most accurate single parameter for estimating GA than other biometric indices in late 2nd and 3rd trimester and could be easily incorporated into the models for estimating GA. We evaluated role of FKL in estimation of gestational age (GA) in late 2nd & 3rd trimester. A total of 98 pregnant women with singleton pregnancy underwent serial biometric & FKL measurements ultrasonographically at 24, 28, 32, 36 and 38 weeks of gestation. These measurements were used to date the pregnancies relative to dating by last menstrual period. Linear regression models for estimation of GA were derived from the biometric indices and FKL. New models were constructed by combining different biometric indices and kidney length in various combinations. Comparison of accuracy in prediction of GA was made between individual parameters and these models to obtain best individual parameter and the best model in prediction of gestational age. Left FKL was slightly, but significantly longer than right FKL at each gestational period observed in the study. Standard error of prediction of GA was least for FKL (±8.56 days), closely followed by femur length (±8.9 days) and maximum for abdominal circumference (±11.72 days). The best model in estimating GA included all the five variables (femur length, FKL, biparietal diameter, head and abdominal circumference) with a standard error of ±7.41 days. FKL is the most accurate single parameter for estimating GA than other biometric indices in late 2nd and 3rd trimester and could be easily incorporated into the models for estimating GA.

Key Words

Gestational age, Fetal Kidney Length, Pregnancy

Introduction

Accurate GA estimation is very important to an obstetrician for diagnosis of growth disorders, in assessment of wrong dates or forgotten dates and timing of delivery either by induction or caesarean section. It is particularly important in high risk pregnancies (severe preeclampsia, chronic hypertension, severe IUGR, central placenta previa, sensitized Rh-negative mother etc) where in some cases early termination may become necessary as soon as fetus becomes mature. GA estimation is also a prerequisite to interpret certain tests (amniotic fluid assay, serum assay, chorionic villus sampling) and to plan timing of various forms of fetal therapy. Failure in estimating GA accurately can result in unnecessary induction, dysfunctional labor, operative delivery, iatrogenic prematurity or postmaturity, false interpretation of tests and delay or failure of fetal therapy, thereby increasing perinatal morbidity and mortality. GA has traditionally been estimated from the date of first day of last menstrual period (LMP). The fallacy in this method is that the time of ovulation in relation to the menstrual cycle varies greatly both from cycle to cycle and individual to individual. About 10-45% of pregnant women cannot provide useful information about their LMP and 18% of women with certain menstrual dates have significant differences between menstrual and ultrasonographic dating.(1). Anderson *et al* (2) demonstrated in a cohort of women that only 71% could accurately recall the date of their LMP. Further, factors such as menstrual abnormalities, lactational amenorrhea, oral contraceptive failure, bleeding in early pregnancy and chronic

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anovulation may interfere with accurate calculation of GA from the date of LMP. Ultrasonographic fetal biometry is the most widespread method used to establish GA. Various sonographic biometric parameters commonly used are Crown Lump Length (CRL), Biparietal diameter (BPD), Head circumference (HC), Abdominal circumference (AC) and Femur length (FL). CRL measurements accurately predict GA to within ± 5-7 days but can be employed only in cases who present in 1st trimester (3). In early 2nd trimester BPD, FL, HC and AC can predict GA with fair accuracy (±10-11days, ±10-20 days, ±10-14 days and ±10-14 days respectively.(3) However as the pregnancy advances these parameters become increasingly unreliable in prediction of GA(4). Therefore accurate estimation of GA in late 2nd and 3rd trimester still remains a problem. Various non-traditional sonographic parameters for estimating GA are being studied like transverse cerebellar diameter, fetal foot length, epiphyseal ossification centers, amniotic fluid volume and placental grading (5). FKL is one such non-traditional parameter for estimating GA under study. It is easy to identify and measure. It is strongly correlated to GA and its linear growth during gestation has been demonstrated on MRI also (6,7,8). It is more accurate method of GA estimation than BPD, FL, HC and AC after 24th week of gestation (6,9). In this longitudinal study we sonographically measured FKL, evaluated its role in estimation of GA and compared its accuracy with other established biometric indices.

Material and Methods

After obtaining informed consent, 129 women were recruited in the study. Inclusion criteria were: women with 28 days regular menstrual cycle, who were certain of their LMPs, whose difference between LMP and ultrasound calculated GA by CRL measurements was < 5 days and who carried a singleton uncomplicated pregnancy. The study was approved by ethical committee of hospital.

Each of them was subjected to serial ultrasonographic biometry and FKL measurements at 24, 28, 32, 36 and 38 weeks of gestation. Same radiologist performed all the measurements using a 2D real-time mode with GE Logic 200 Pro 2.5 to 5 MHz convex probes. Biometric measurements were obtained using well defined reference points.(10,11,12,13,14) and FKL measurements obtained as described by Konje JC.(6) The fetus was scanned in the transverse plane until the kidneys were visualized just below the stomach. The probe was then rotated through 90degree to outline the longitudinal axis of the kidneys. Markers were placed on the image of the renal capsule, taking care to exclude the adrenal gland. Lower pole of the kidney was clearly distinguished from the gastrointestinal tract. All measurements were obtained during fetal apnea. Women who developed any pregnancy related complication, any fetal growth disorder, amniotic fluid abnormalities, abnormal renal morphology and in whom adrenal and renal borders could not be visualized clearly were excluded from the study. The data was then analyzed using computer software MS-Excel and SPSS 12.0 for windows. At each GA, FKL and other biometric indices were reported as Mean ± SD. Pearson's correlation between various maternal parameters (age, weight and height) and GA was calculated. Spearman's correlation between parity and GA was also calculated. Correlation between GA and FKL as well as correlation between GA and other fetal biometric indices were presented in the form of scatter plots and assessed by using Pearson's product moment correlation coefficient. Its significance was assessed by the use of T-test. To predict GA by using FKL measurements and other biometric indices, multiple linear regression analysis was performed using linear mixed model approach taking GA as dependent variable and fetal biometric indices as independent variables. New models were constructed by including BPD, FL, AC, HC and KL (average of left & right FKL) in various combinations. Determination of best model was based on Akaike information criterion (AIC), r2 and the standard error of prediction (SEpred). For each model the standard error of prediction in days was calculated for subjects with mean value of anthropometric measurement included in the model. A 5% statistical significance level was used to reject the null hypothesis that there was no evidence of a linear relationship.

Results

Out of 129 women recruited in the study group only 98 completed the study. Women excluded from the study included those who had pregnancy induced hypertension (9), intrauterine growth restriction with oligohydramnios (4), abnormal glucose tolerance test (1), preterm labour (2), premature rupture of membranes (4) and who did not report during follow up scans (11). Mean age, height and weight of the women were 24.98±3.80 years (19-35), 155.16±3.79 cms (146-165) and 56.05±5.24 kgs (45-

Table 1. Comparison of Left and Right Kidney Length at Different Periods of Gestation

GA (weeks)	LK (mm) Mean ± SD	RK (mm) Mean ± SD	Difference (mm)	Paired t-test	KL (mm) Mean ± SD
24	26.04±1.88	25.43±1.68	0.61	0.000(p<0.001)	25.73±1.76
28	31.93±1.70	31.12±1.71	0.81	0.000(p<0.001)	31.52±1.67
32	36.89±1.64	36.12±1.58	0.77	0.000(p<0.001)	36.50±1.56
36	40.97±1.69	40.19±1.67	0.78	0.000(p<0.001)	40.58±1.61
38	42.17±1.63	41.35±1.65	0.82	0.000(p<0.001)	41.75±1.55

LK-left kidney length, RK-right kidney length, KL-average of left & right kidney lengths

Table 2. Linear Regression Equations Defining The Relationship Between GA And The Various Indices For GA Estimation Between 24 And 38 Weeks' Gestation

Parameters	Equation	AIC	r^2	SE_{pred} (days)
FL, KL	GA=4.700+2.087*FL+0.409*KL	1664.31	93.5	7.66
FL, KL, BPD	GA=4.094+1.748*Fl+0.324*KL+0.722*BPD	1653.71	93.7	7.59
Fl, KL, HC	GA=4.305+1.937*FL+0.367*KL+0.101*HC	1665.00	93.6	7.52
Fl, KL, AC	GA=4.808+1.927*FL+0.367*KL+0.089*AC	1662.01	93.6	7.65
FL, KL, BPD, AC	GA=4.229+1.627*FL+0.291*KL+0.676*BPD+0.0793*AC	1652.84	93.8	7.47
FL, KL, BPD, HC	GA=3.827+1.652*FL+0.295*KL+0.683*BPD+0.076*HC	1655.76	93.7	7.63
FL, KL, BPD, HC, AC	GA=4.122+1.603*FL+0.284*KL+0.66*BPD+0.0274*HC+0.073*AC	1656.41	93.8	7.41

SE - Standard error, AIC - Akaike Information Criterion, SEpred - Standard error of prediction, KL-average of left and right kidney, BPD-biparietal diameter, FL-femur length, HC-head circumference, AC-abdominal circumference, GA- gestational age

Table 3. Comparison of the Accuracy of the Prediction of GA by the Various Models (Incorporating Kidney Length) Between 24 and 38 weeks' Gestation

Parameters	Equation	AIC	r^2	SE_{pred} (days)
FL, KL	GA=4.700+2.087*FL+0.409*KL	1664.31	93.5	7.66
FL, KL, BPD	GA=4.094+1.748*Fl+0.324*KL+0.722*BPD	1653.71	93.7	7.59
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AIC - Akaike Information Criterion, SEpred - Standard error of prediction, GA-gestational age

67) respectively. Average FKL increased from 25.7mm at 24 weeks of gestation to 41.7 at 38 weeks of gestation in our study. Mean left FKL was slightly but significantly longer than mean right FKL at each gestational period observed in our study (*Table 1*). There was a statistically highly significant correlation between GA (weeks) and various biometric parameters including FKL (BPD; r=0.952), (FL; r=0.958), (HC; r=0.944), (AC; r=0.921), (KL; r=0.959). *Table 2* shows the equations derived from linear regression analysis when individual variables were considered separately. FKL was the most accurate single parameter in predicting GA with a standard error (SE) of 8.56 days while AC was most inaccurate with a SE of 11.72 days. The models derived from various biometric

indices and the equations obtained by regression analysis between these indices and GA is presented in *table 3*. It also shows the accuracy of precision (SE) with which GA was estimated by using these models. The most accurate model in estimating GA was the one which included all the five biometric indices (BPD, FL, AC, HC and KL). No correlation was found between FKL and mother's age, height, weight and parity with 'p' value being not significant for all of them.

Discussion

The biometric indices used in second trimester continue to be used in third trimester despite substantial evidence indicating that the SD for these measurements widens with advancing gestation and therefore were likely to be more inaccurate as the GA progresses. In a hunt to discover a method which could accurately predict GA even in advanced stages of gestation, various non traditional methods have been evaluated like fetal transcerebellar diameter, fetal foot length, epiphyseal ossification centers, amniotic fluid volume, placental grading, placental thickness, FKL, colonic echogenecity and transverse diameter of colon. In this study we evaluated the role of FKL measurements in estimation of GA and compared its accuracy with other fetal biometric indices. Cohen *et al* (7) stated that unless the fetus was prone with its back facing the transducer, only the borders of near kidney could be measured. Duval et al(16) encountered difficulty in imaging kidneys in breech presentation and in vertex presentations with back facing laterally or posteriorly. However, no such difficulty was experienced in our study. A little manipulation of the transducer position and angle of insonation relative to the kidney plane allowed easy identification of both kidneys which is in agreement with Konje *et al* (6). There was no case in which both kidneys were not measurable.

The mean BPD, FL, HC and AC measurements at various gestations observed in our study were similar to measurements obtained by previous authors (10,14). The variability of the FKL and other biometric measurements about the mean observed in our study was noticeably less than that observed in previous studies (6,10-15).

Many authors reported no significant difference between left and right FKL measurements (6,9,17-19) Left FKL was slightly, but significantly, longer than the right FKL in the study by Fitzsimons *et al*.(20) Duval *et al* (16) and Sampaio *et al* (21) in their study found left FKL to be longer than right FKL at the end of intrauterine life. The left kidney was longer than the right in neonates with body length more than 43 cms and this difference became more significant as the body length increased in a study by Gonzales (22). In our study the mean left FKL was slightly, but significantly, longer than the mean right FKL at each gestational period observed in the study. This finding was consistent with the study of Fitzsimons (20).

We found a very strong correlation between FKL and GA as compared to previous studies. The correlation coefficient (r=0.958) observed in our study was higher as compared to Cohen *et al* (1991) (r=0.82), Schlesinger *et al* (1987) (r=0.859), Gloor *et al* (1997) (r=0.90), Chiara *et al* (1989) (for RK r=0.84, for LK r=0.87) and Konje *et al* (2002) (r=91) (6,7,17,18,23). Correlation coefficients between GA and other biometric indices were also higher as compared to previous studies (6). A number of reasons could explain these differences. These include number of sonologists (single vs. multiple), type of study (longitudinal vs. cross-sectional), quality of ultrasonography machine (new vs. old), characteristics of subjects (only uncomplicated pregnancies vs. all pregnancies) and observer bias (non-blind vs. blind study).

In our study FKL was the most accurate single parameter for the estimation of GA closely followed by FL. AC was the most inaccurate single parameter for estimation of GA according to our study. These findings were consistent with the findings of Konje *et al* (6)

The models obtained by combining different parameters were more accurate in estimation of GA as compared to individual parameters. This observation was consistent with the study of Hadlock *et al* (24) The best model in prediction of GA in our study was one which included all the five parameters (KL, FL, BPD, HC, and AC). This finding is also consistent with the finding of Konje *et al* (6). No correlation was found between FKL and mother's age, height, weight and parity in our study. These observations were in concordance with the study of Cohen *et al* and Yusuf *et al.*(7,8)

Conclusion

FKL is easy to identify and measure. It is the most accurate single parameter for estimating GA than other biometric indices in late 2nd and 3rd trimester and could be easily incorporated into the models for estimating GA. It could prove to be a valuable tool in cases where other established biometric indices are difficult to obtain show gross discrepancies with each other or with GA.

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