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ORIGINAL RESEARCH

Sonographic Correlation of Gestational Age with Fetal Kidney Length

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ABSTRACT

Background: Gestational age estimation is one of the most important information conveyed by a sonologist when performing an obstetric ultrasound examination. The traditional fetal biometric parameters, such as biparietal diameter (BPD), head circumference (HC), femur length (FL), and abdominal circumference become increasingly unreliable for accurate gestational age estimation with advancing pregnancy, especially in 3rd trimester. This study was conducted to assess the role of fetal kidney length (KL) as an alternate parameter to assess gestational age in 2nd and 3rd trimesters.

Aim: To assess relationship between sonographic gestational age and fetal KL between 18 and 39 weeks of gestation.

Settings and design: Prospective, cross-sectional, single operator study conducted over a period of 1 year in a medical college hospital.

Materials and methods: Three hundred singleton pregnant women between 18 and 39 weeks of gestation were subjected to antenatal ultrasound. In addition to routine fetal biometry, measurements of fetal KL were made by noting distance between upper and lower poles of each kidney on a sagittal section of the fetal abdomen. The right and left KLs were averaged to obtain a single value for the purpose of statistical analysis.

Statistical analysis: Statistical analysis is done using SAS 9.2, SPSS 15.0, Stata 10.1, Med Calc 9.0.1, Systat 12.0, and R environment version 2.11.1. Fetal KL was expressed as mean ± standard deviation. Linear regression analysis was used to establish a relationship between sonographic gestational age in weeks and fetal KL. Level of significance was expressed as p value.

Results: A strong statistical correlation was found between sonographic gestational age and fetal KL. Nomograms and growth curves were constructed to correlate gestational age with fetal KL.

Conclusion: Fetal KL measurements can be used as alternate method of estimating gestational age in women with uncertain last menstrual periods (LMPs) and presenting late in the gestation for safe confinement. In fetal macrocephaly, hydrocephalus, short-limb dysplasias, and when fetal head is engaged, these measurements are valuable alternate parameters to assess gestational age since they are simple, not time-consuming, easy to identify, and measure.

Keywords: Fetal kidney length, Gestational age, Sonography.

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INTRODUCTION

Gestational age estimation is one of the most important information conveyed by a sonologist when performing an obstetric ultrasound examination. It not only provides a noninvasive estimate of the average gestational age but also serves as a baseline for estimating the interval fetal growth in all future obstetric ultrasound studies during the pregnancy. In 2nd trimester, it helps to optimize the timing of amniotic fluid assay and maternal serum assays.[1] During 3rd trimester, it helps to plan timing of fetal interventional therapy when indicated, for diagnosis of fetal growth disorders, and in high-risk pregnancies, such as those complicated by gestational hypertension, preeclampsia, central placenta previa, and sensitized Rh negative mothers where delivery is timed as soon as the fetus becomes mature.[1] Failure in estimating the gestational age accurately can lead to false interpretation of tests, unnecessary induction of labor, operative delivery, and iatrogenic prematurity, all of which contribute to increased perinatal morbidity and mortality.[1]

Gestational age has traditionally been estimated from the 1st day of the last menstrual period (LMP) using Naegle's rule. The limitation of relying solely on this method is that the timing of ovulation varies greatly between individuals and menstrual cycles in the same

individual. Also, many women may not be able to recall the date of their LMPs accurately.[1,2]

Fetal biometry using ultrasound is the most popular method to estimate gestational age worldwide. In 1st trimester, the gestational sac volume, diameter, and fetal crown rump length can accurately predict gestational age within 5 to 7 days.[3,4] In early 2nd trimester, a combination of biparietal diameter (BPD), head circumference (HC), femur length (FL), and abdominal circumference can predict gestational age with an accuracy of ± 10 to 14 days.[5] As the pregnancy advances, these parameters become increasingly unreliable in predicting the gestational age.[6] Therefore, accurate gestational age assessment in 3rd trimester still remains a concern. Various nontraditional sonographic parameters for estimating gestational age have been studied, such as transcerebellar diameter, clavicle length, epiphyseal ossification centers, amniotic fluid volume, colonic echogenicity, transverse diameter of the colon, placental grading, thickness, etc.[1,7] Some authors have found a strong correlation of fetal sacral length, hard palate width, length, and area with gestational age in 2nd and 3rd trimesters.[8,9] Fetal kidney length (KL) is one such alternate parameter to assess gestational age in 2nd and 3rd trimesters. In this study, we prospectively measured fetal KL and attempted to correlate it with sonographically estimated gestational ages. We also derived a nomogram and growth curve of the fetal KL at various gestational ages ranging from 19 to 39 weeks.

MATERIALS AND METHODS

Three hundred pregnant women between 18 and 39 weeks of gestation were recruited into this prospective, cross-sectional study after obtaining their written, informed consent. Our inclusion criteria were women with singleton pregnancies who were certain of their LMPs, who had previous regular menstrual cycles, who had undergone a 1st trimester dating scan, who had a normal anomaly scan between 20 and 24 weeks, and with normal amniotic fluid volume. Women whose fetuses had or were suspected of having intrauterine growth restriction, chromosomal, or structural abnormalities, oligo/polyhydramnios (amniotic fluid index of <5 cm or >25 cm), dilated renal pelvis (renal pelvis width >4 mm), and women with pregnancies complicated by any medical, surgical, or obstetric disorders were excluded from the study. The study was conducted over a 1-year period from March 2013 to March 2014 at Yenepoya Medical College, Mangaluru after being approved by the hospital ethical committee.

Each patient underwent a detailed antenatal ultrasound study in which, in addition to routine fetal biometry of BPD, HC, FL, and abdominal circumference, measurements of each fetal KL were made. A single radiologist performed these measurements using two-dimensional (2D), real-time, grey scale PHILIPS Envisor C-HD and GE Voluson 730 Expert ultrasound equipments with 2 to 5 MHz curvilinear transducers.

Fetal KL was measured from one outer pole to another, as described by Bertagnoli et al.[10] The adrenal glands were first identified and excluded from the measurements. All the measurements were performed during fetal apnea. The fetus was initially scanned in the transverse plane until the kidneys were visualized below the stomach. The transducer was then rotated by 90° to outline the longitudinal axis of the kidneys. At upper pole of the kidneys, care was taken to exclude adrenal gland; while at the lower pole, the gastrointestinal tract was excluded from the measurements. The right and left kidneys were measured twice, one mean value was taken for each of the kidneys which was then averaged to obtain a single measurement for the purpose of statistical analysis. Whenever the fetal position was inappropriate, the ultrasound study was repeated after 30 to 45 minutes (Fig. 1).[11]

The statistical software used for analysis were SAS 9.2, SPSS 15.0, Stata 10.1, Med Calc 9.0.1, Systat 12.0, and R environment version 2.11.1. Microsoft Excel was used to generate the graphs and tables. At each gestational age in weeks, the fetal KL was calculated from the raw data and expressed as mean ± standard deviation (SD). Linear regression analysis was used to establish a relationship between sonographic gestational age in weeks and fetal KL, and to derive an equation to predict the gestational age in weeks from the fetal KL measurements. Level of significance was expressed as p value and a p-value of <0.01 was taken as strongly significant. Nomograms and growth curves were constructed to correlate gestational age in weeks with fetal KL measurements.

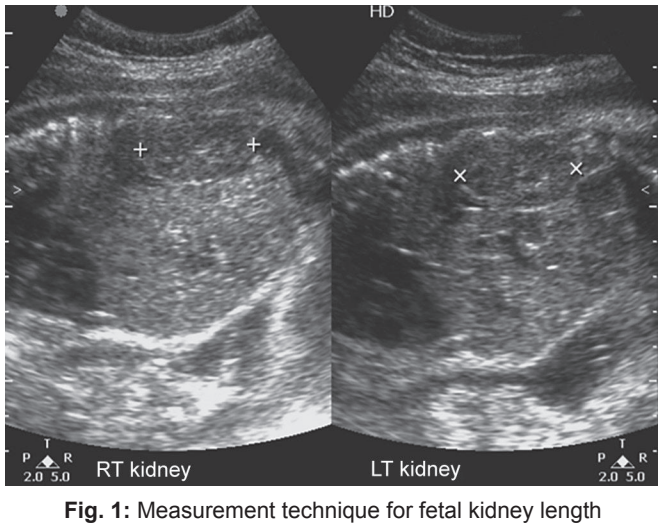


Fig. 1: Measurement technique for fetal kidney length

RESULTS

Table 1 shows that 59% of our patients were between 28 and 37 weeks; followed by 15.3% between 22 and 28 weeks; 15% less than 22 weeks; and 10.7% between 37 and 40 weeks of gestation.

A strongly significant linear statistical correlation was found between sonographic gestational age and fetal KL with p-value of <0.001 and R^2 value of 95%. Also, there was no statistically significant difference between the right and left fetal KL measurements in our study. The changes in the fetal BPD, HC, FL, and abdominal circumference with advancing gestation were as reported previously in other studies (Table 2 and Graphs 1 and 2).

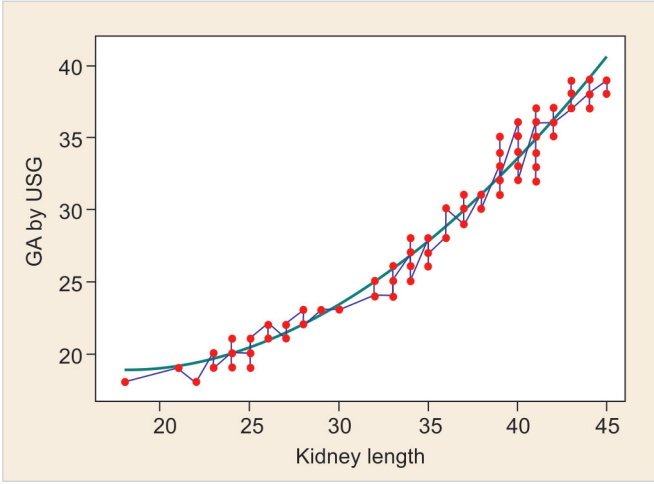
Table 1: The total number and percentage of patients of less than 22 weeks, 22 to 28 weeks, 28 to 37 weeks, and 37 to 40 weeks of sonographic gestational ages

Gestational age (by USG)	*No. of patients*	*Percentage*
<22 weeks	45	15.0
22–28 weeks	46	15.3
28–37 weeks	177	59.0
37–40 weeks	32	10.7
Total	300	100.0

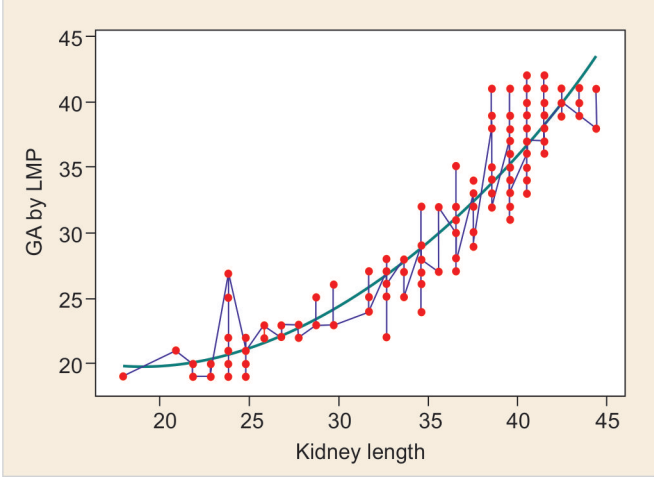
Table 2: A nomogram of the relationship between sonographic gestational age in weeks and fetal kidney length in our study

Gestational age by USG (weeks)	*No. of patients*	*Percent of patients*	*Kidney length in mm*
19	8	2.67	23.25±1.58
20	12	4.00	23.92±0.67
21	17	5.67	24.82±1.01
22	11	3.67	26.64±0.81
23	11	3.67	29.45±0.69
24	6	2.00	32.17±0.41
25	11	3.67	33.18±0.75
26	4	1.33	34.25±0.96
27	7	2.33	34.86±0.38
28	5	1.67	35.00±0.71
29	4	1.33	37.00±0.00
30	10	3.33	37.40±0.70
31	11	3.67	38.09±0.83
32	13	4.33	40.00±0.58
33	13	4.33	39.85±0.69
34	28	9.33	40.54±0.58
35	52	17.33	40.96±0.63
36	41	13.67	41.27±0.55
37	19	6.33	42.32±0.82
38	8	2.67	43.88±0.64
39	5	1.67	43.80±0.84
Total	300	100.00	
Regression 1	Gestational age by USG (weeks) = –2.482 + 0.905 × kidney length, R^2 = 94.9%, p<0.001**		

**The p value of <0.001 indicates that the relationship between fetal KL and gestational age has a strong statistical significance A p value between 0.05 and 0.01 indicates that the relationship between the above variables is of moderate statistical significance and a p value between 0.05 and 0.10 indicates suggestive significance



Graph 1: A scatterplot of sonographic gestational age *vs* fetal kidney length in our study



Graph 2: A scatterplot of menstrual gestational age *vs* fetal kidney length in our study

DISCUSSION

With rapid technological advances in ultrasound imaging and widespread availability of high-resolution ultrasound equipments, it is much easier to identify and accurately measure the fetal kidneys today than it was few years ago.

The fetal kidneys develop in a complex but distinctive sequential pattern, beginning around the 7th to 8th week of gestation and continuing up to 35 to 36 weeks.[12,13] Maternal obesity can hinder optimal visualization of fetal kidneys. The fetal kidneys are difficult to identify sonographically before 17 weeks of gestation. However, they are imaged in about 90% of fetuses between 17 and 22 weeks of gestation. During 2nd trimester, the fetal kidneys appear sonographically as oval-shaped hypoechoic structures in the retroperitoneum surrounding the slightly more echogenic pyelocalyceal sinus but lack distinct borders. As the kidneys develop, the pelvicalyceal system becomes more conspicuous. At about 27 weeks

of gestation, the renal pyramids and a distinct capsule become apparent.[14] With advancing gestational age, the gradually progressive deposition of perinephric fat aids in accurate identification of renal borders by distinguishing it from adjacent soft tissues.[14,15] By about 30 weeks of gestation, there is sufficient perinephric fat accentuating the renal outline to make its identification easy and accurate.[16] Studies have indicated that fetal growth variations predominantly affect the anteroposterior and transverse diameters of the fetal kidneys and KL remains unchanged in small-for-gestational age fetuses.[12,14,15]

The fetal kidneys were studied on antenatal sonography in 397 patients by Cohen et al[15] who concluded that a strong statistical correlation exists between renal length and sonographic gestational age. The fetal renal length measurements in our study correlate closely with those of Cohen et al. Their study found that unless the fetus is prone with its back facing the transducer, usually only the borders of the near kidney can be imaged adequately. Yusuf et al[16] in their study found that the mean fetal KL in millimeters approximates the gestational age in weeks in 3rd trimester.

Duval et al[17] encountered difficulty in imaging both fetal kidneys in breech presentation and in vertex presentation with back facing laterally or posteriorly. However, in our study, we found that a little manipulation of the transducer position and angle of insonation allowed easy identification of both fetal kidneys. This is in agreement with Kaul et al[1] and Konje et al.[11] There was no case in which both fetal KLs were not measurable.

From Table 3, it is clear that the mean fetal KLs in our study correlate closely with those of Cohen et al but are significantly longer than those of Kansaria and Parulekar[14] and Konje et al.[11] There may be several reasons for this type of study (longitudinal in the first two studies *vs* cross-sectional in the last two including our study), number of sonologists involved in the study (single *vs* multiple), quality of ultrasound equipment used (old *vs* new), estimation of gestational age (round *vs* exact), inclusion criteria of patients in the study, observer bias, and racial/ethnic differences in the patient population.

Table 3: A comparison of the mean fetal kidney lengths in three previous studies with our study

Gestational age in weeks	*Mean fetal kidney length in mm (Kansaria and Parulekar)*[14]	*Mean fetal kidney length in mm (Konje et al)*[11]	*Mean fetal kidney length in mm (Cohen et al)*[15]	*Mean fetal kidney length in mm (our study)*
24	23.8	24.2	31	32.1
26	25.2	26.3	34	34.2
28	26.9	29.0	34	35.0
30	29.0	30.9	38	37.4
32	30.8	33.2	41	40.0
34	32.5	35.0	42	40.5
36	34.2	38.2	42	41.2
38	36.2	40.1	44	43.8

In our study, we found no statistically significant difference between the left and right fetal KL measurements at each gestational age. The findings in several studies were consistent with those of our study.[11,12,14] Left fetal KL was slightly but significantly longer than the right KL in the study by Fitzsimons[18] and Kaul et al.[1] Similarly, Duval et al[17] and Sampaio et al[19] in their study found fetal left kidney to be longer than right kidney at the end of intrauterine life.

Konje et al[11] conducted a prospective, "two-operator" longitudinal study and found that fetal KL is the single-most accurate parameter for predicting gestational age in 2nd and 3rd trimesters and is therefore, valuable in circumstances where the fetal BPD or HC cannot be measured because the fetal head is too low or the correct plane of measurement cannot be obtained. Studies conducted by Kaul et al[1] and Kansaria and Parulekar[14] demonstrated similarly that fetal KL is more accurate than the routine biometric indices for estimating gestational age in late 2nd and 3rd trimesters and could be easily incorporated into the models for gestational age estimation. Kansaria and Parulekar[14] additionally concluded that by measuring fetal KL, pregnancies could be dated within 9.17 days in the 2nd and 3rd trimesters and KL grows at an average rate of 1.7 mm fortnightly. Toosi and Rezaie-Delui[12] found that the most accurate gestational age predictor in 3rd trimester was obtained by combining fetal HC, BPD, FL, and KL with a standard error of about 14.2 days. Many studies have found that the fetal KL measurement in preterm/premature neonates are similar to those of term/mature neonates of equivalent gestational ages.[20,21]

Knowledge of the normal fetal kidney length is also useful in the early diagnosis of abnormal renal development, especially when associated with nephromegaly or renal hypoplasia. This is especially true if the renal echotexture is apparently normal, as may occur in some cases of early congenital polycystic diseases of the kidney.[15] Some common congenital fetal renal malformations that can manifest with altered renal length include renal agenesis, hypoplasia, polycystic kidney disease, pelvic-ureteric junction obstruction, and hydronephrosis.

CONCLUSION AND CLINICAL SIGNIFICANCE

In a country like ours with a large rural population where all women may not be able to accurately recall the date of their LMPs and present late in the gestation for booking/safe confinement, fetal KL measurement is

a valuable alternative tool to estimate the gestational age in 2nd and 3rd trimesters. In fetal macrocephaly, hydrocephalus, short-limb dysplasias, and late 3rd trimester when fetal head is engaged, fetal KL measurement alone is extremely useful to assess the gestational age since it is simple to perform, not time-consuming, easy to identify and measure, and is of proven accuracy. We hope that in the years to come, fetal KL estimation will gain wider acceptance among the sonologists' community and will be successfully incorporated into the routine fetal biometric measurements for gestational age estimation in 2nd and 3rd trimesters.

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