Original Article

Fetal Kidney Length: A Likely Sole Index for Gestational Age Determination in Late Pregnancy and Certain Abnormalities

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Abstract

Background: The Obstetric management of a pregnancy relies on the knowledge of an accurate gestational age especially in unregistered cases. **Aims:** The aim of this study was to sonographically evaluate the fetal kidney length as a potentially dependable direct measurement parameter, to estimate gestational age in the second and third trimesters. **Patients, Materials and Methods:** The study involved 236 participants with 20 to 34 weeks pregnancies, referred to the Radiology department of the University of Calabar teaching hospital for obstetric ultrasound scan, within a three-month period. The fetal kidney lengths were measured, in addition to the routine parameters, which included head circumference and femur length. The estimated gestational ages derived from the routine parameters, were correlated with the kidney and femur lengths and head circumference. The data were analyzed using SPSS version 22.0. **Results:** Fetal kidney length increased in direct proportion to gestational age. It had a significant positive correlation coefficient (0.982) with the estimated gestational age, similar to the head circumference and femur length. Fetal kidney lengths in millimeters were nearly equal to the estimated gestational ages in weeks, especially from the thirtieth week. **Conclusion:** Fetal kidney length is a viable, simple and direct method for determination of gestational age of pregnancies in the second and third trimesters. Since fetal kidney length assessment is said to remain reliable after 34 weeks, unlike the head circumference and femur length, it can serve as the sole index of gestational age assessment late in pregnancy, especially in fetal structural abnormalities.

Keywords: Fetal kidney length, gestational age, ultrasonography

Introduction

An important tool in managing pregnancy is an accurate estimated gestational age (EGA) alongside a corresponding estimated date of delivery (EDD). Obtaining this tool forms the basis for an objective assessment of fetal growth in the course of pregnancy.[1] An appropriately conducted ultrasonography is essential in achieving this goal since many women often state wrong last menstrual periods (LMPs) and some have an irregular menstrual cycle, with resultant inaccurately calculated EDD. Besides, the EGA derived from an ultrasonographic examination is more dependable than the LMP presented by a pregnant woman.[1,2]

Ultrasonographic evaluation of the fetus to determine EGA is most accurate in the first trimester of pregnancy (up to and including 13 weeks six days) and least in the third trimester. The occurrence of unnecessary postterm induction of labour drastically reduces with an accurate determination of the EDD using ultrasonography.[1] This will also curtail the delivery of a premature fetus assigned a wrong gestational age in rupture of membrane which will be consequently prone to perinatal morbidity and mortality.[3]

In a search for an accurate fetal ultrasound biometric parameter for EGA determination in the second trimester, the fetal head circumference (HC) on its own correlates better with the fetal EGA than the fetal bi-parietal diameter (BPD), abdominal circumference (AC), and femur length (FL). However, it becomes less reliable with increasing gestational age.[2] Papageorghiou *et al*. found out that the addition of FL to

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HC, rather than being used solely, considerably improves the accuracy of fetal EGA determination.[4]

It is worrisome also to note that on some occasions, ultrasonographic procedures may assign a higher EGA to a large-for-gestational-age fetus or a lower EGA to a small-for-gestational-age fetus due to growth discordance.[2] The lack of correct EGA estimation, especially in geographical regions at a higher risk of manifesting this growth discordance, means that the rates of preterm deliveries and small-for-gestational-age pregnancies are mere approximations in the different parts of the world.[4,5]

There is presently no single parameter that can be used to accurately calculate the fetal gestational age within the 3rd trimester, especially beyond 34th weeks of gestation.[6] This is of utmost concern to obstetricians managing pregnant women that book late with a wrong LMP or unsure of their LMP.[6,7]

The fetal kidneys are conspicuous in about 95% of cases at the 20th week of gestation and they usually lie on each side of the fetal spine. It is not affected by fetal growth anomalies except those that affect the urinary system such as obstructive uropathy in utero.[8-10] From the 34th week of gestation upward the measured routine fetal biometric indices using ultrasonography are unreliable to determine accurate EGA and EDD.[11] Hence, the search for a single reliable biometric parameter that must first be as accurate as the HC and FL between 20 and 34 weeks and have a potential to be more accurate than these two routine parameters between 34 and 40 weeks of pregnancy. Fetal kidney length (FKL) measurement was found to be optimal in determining the gestational age between the 24th and 38th weeks of pregnancy, making it more reliable than the established fetal biometric indices (BPD, HC, FL, and AC).[12]

This research aims to sonographically measure the FKL and correlate the values with the composite EGA obtained from the current standard parameters (BPD, HC, FL, and AC) to determine its reliability as a biometric tool between 20 and 34 weeks.

Patients, Materials and Methods

Study design

This research was a prospective, cross-sectional study carried out at the Radiology Department, University of Calabar Teaching Hospital (UCTH), Calabar, Cross River State. The study involved 236 healthy pregnant women seen between August and October 2021.

The participants involved in this study were healthy singleton pregnant women with normal ultrasound between 20 and 34 weeks of gestation referred from the antenatal clinic for their routine obstetric scan. Ethical approval for the research was obtained from the health research ethics committee of the (UCTH/HREC/33/5134). Consent forms and questionnaires were administered to the participants.

The inclusion criteria are as follows: uncomplicated singleton pregnancy with prior regular menstrual cycle and pregnancies within 20–34 weeks gestational ages.

The exclusion criteria are as follows: pregnancy-induced hypertension, gestational diabetes, pulmonary tuberculosis, human immunodeficiency virus, intrauterine growth restriction IUGR, oligohydramnios, polyhydramnios, multiple pregnancies, fetal weight below the 10th percentile and above the 90th percentile for the corresponding gestational age, congenital anomaly, nuchal cord, fetal hydronephrosis, fetal renal pelvis dimension that is wider than 5 mm, hydrops fetalis, and fetal renal abnormality.

Equipment

The equipment used was a Toshiba TUS-X100S (Xario 100), 2015 Ultrasound machine. The curvilinear probe (3.5–5MHz) and 2-Dimensional protocol with Doppler facility were deployed.

Data collection tool and procedure

The transabdominal approach was used to evaluate the fetal kidneys in the participants. A chaperon was present to make the women comfortable and assuage any form of distress that may have been felt during the procedure. The two researchers for this study agreed on the appropriate landmarks and points to take measurements at the poles of the fetal kidney.[6,9] Some measurements were cross checked on some patients to confirm compliance, reducing inter-observer errors before commencing the research and data collection.

The pregnant women were made to lie supine and a generous amount of coupling gel was applied to the abdomen before commencing the scan. In addition to HC and FL values obtained during the protocol for routine obstetric scan, the right FKL was measured after identifying its anatomic landmark (spine). The EGA was derived from the algorithm installed in the ultrasound machine.[13]

The fetal kidney is recognized by approaching the renal bed with the transducer from the level where the fetal AC is estimated.[9] The right kidney is seen in the transverse view at a level below the stomach and then the transducer is rotated through 90°. This allows the fetus to appear in a longitudinal plane where the entire length of the fetal kidney is appreciated, beside the fetal spine. A caliper is placed at the superior pole of the fetal kidney from where a line is then drawn to the inferior pole to measure the FKL [Figure 1]. Complete care was taken to exclude the adrenal glands from the measurement of the kidney to prevent over-estimation. Three measurements were done for all measured parameters, and the average was obtained to reduce intra-observer error.[6,9,14,15] The right fetal kidney was evaluated in this study because the measurement of both kidneys is statistically the same in length in most cases.[16]

The data obtained were analyzed using the IBM Statistical Package for the Social Sciences (IBM SPSS) software for Windows (IBM SPSS Inc.,Chicago, Illinois,USA) version 22 and Microsoft Excel 2019 MSO (version 2109).

Appropriate descriptive (including simple proportions and percentages) and inferential statistical methods were applied on the data. The continuous variables were reported as means and standard deviation.

The correlation between FKL and the derived EGA from standard biometric parameters was determined by using Pearson's correlation. Statistical significance was defined at a *P* value that is < 0.05.

Results

Two hundred and fifty-four participants were initially recruited, but 18 were dropped. The reasons for excluding the 18 participants were the presence of hydronephrosis, twin pregnancy, and difficulty in clearly defining the margins of the right kidney. Two hundred and thirty-six participants were finally involved in the study, and their mean age was 30.64 ± 4.53 years, with a range from 20 to 42 years.

Table 1 presents the sociodemographic characteristics, parity, and gestational age of the pregnancy of the study participants. Most of the participants were between the ages of 25 and 34 years representing 71% of the study population. Most (39%) of the participants are multiparous and 45% of the pregnancies were in the 30^{th} to 34^{th} week of gestation. Most had a university degree and were employed.

Table 2 reveals that the average EGA of the fetuses evaluated during the study was 28.44 ± 4.68 weeks. This mean EGA was almost equal to the mean of the FKL measured in millimeters (28.0 mm).

The scatterplot in Figure 2 showed that the measured FKL increased linearly, as the pregnancy advanced toward the 34^{th} week. The gradient of the derived line was 0.1164 implying that the FKL increased at a rate of 1.164 mm per week.

Table 3 showed the mean of the different fetal biometrics each week within the range of gestational age chosen for the study. The mean of the three parameters increased as the gestational increase, except the HC which reduced marginally at 26 weeks from 23.57 ± 0.40 to 23.45 ± 0.040 cm. The length of the fetal kidney was similar to the composite EGA, in comparison to the rough estimate the fundal height gives, using a measuring tape. Furthermore, between the 30^{th} and the 34^{th} week of pregnancy, the measured FKL in millimeters (mm) corresponds to the EGA in weeks.

Table 4 demonstrated the significant positive correlations between each of the measured fetal biometric parameter and the EGA. The three fetal biometric parameters have the same *P* value. However, the correlation coefficient was highest with the HC and lowest with the FKL.

Table 1: Sociodemographic characteristics of the study participants

Variables	Frequency *n* (%)
Maternal age (years)	
20-24	18 (8)
25-29	76 (32)
30-34	92 (39)
35-39	44 (19)
40-44	6 (2)
Parity	
Nulliparity	72 (30)
Primiparity	68 (29)
Multiparity	92 (39)
Grand multiparity	4 (2)
Fetal gestational age (weeks)	
20-24	72 (30)
25-29	58 (25)
30-34	106 (45)
Educational status	
Primary school certificate holder	20 (8)
High school certificate holder	76 (32)
University first degree holder	124 (53)
University second degree holder	16 (7)
Employment status	
Employed	138 (58)
Unemployed	98 (42)

Table 2: Mean of the measured fetal indices, estimated gestational age, and estimated fetal weight

	n	Minimum	Maximum	Mean±SD
HC (cm)	236	16.58	31.91	25.60±4.42
FL (cm)	236	3.06	7.01	5.37±1.12
FKL (cm)	236	1.74	3.66	2.80±0.54
EGA (weeks)	236	20.00	34.86	28.44±4.68
EFW (kg)	236	0.30	2.61	1.37±0.72

HC: Head circumference, FL: Femur length, FKL: Fetal kidney length, EGA: Estimated gestational age, EFW: Estimated fetal weight, SD: Standard deviation

Discussion

It was observed in this research that the FKL increased linearly with the gestational age, as shown in the scatter plot in Figure 2. The FKL grew at the rate of 1.164 mm per week of gestation, as depicted by the gradient of the scatterplot. Akram *et al*. in their study in Pakistan, involving 399 participants with pregnancies between 20 and 38 weeks, found out that the right renal length increased by 1.75 mm for every gestational week that elapsed,[9] while Ugur *et al*. in Turkey reported that the FKL increased at a constant rate of approximately 1.7 mm every fortnightly throughout pregnancy.[17]

The measurement of FKL is an objective and reliable means to determine the gestational age of pregnancy when the LMP is uncertain. Moreover, FKL is not affected when other biometric parameters are affected by factors such as IUGR, macrosomia, or conditions that distort the fetal AC and, by implication, the EGA.[9] As gestation advances toward term, the kidneys become very easy to locate and evaluate for fetal age determination.[16] In addition, even though the fetal

Table 3: Mean and frequency distribution of the fetal biometric variables at each gestational age

GA (weeks)	Frequency, *n* (%)	Mean			
		EGA (week)	FKL (cm)	HC (cm)	FL (cm)
20	18 (7.63)	20.38±0.36	1.92±0.13	17.31±0.60	3.35±0.18
21	6 (2.54)	21.79±0.11	2.00±0.05	19.46±0.66	3.58±0.06
22	12 (5.08)	22.61±0.30	2.13±0.06	19.81±0.44	3.96±0.20
23	8 (3.39)	23.39±0.39	2.16±0.12	20.57±0.83	4.34±0.20
24	28 (11.86)	24.31±0.24	2.30±0.10	21.73±0.20	4.37±0.24
25	20 (8.47)	25.60±0.30	2.41±0.12	23.57±0.40	4.82±0.20
26	6 (2.54)	26.25±0.22	2.52±0.04	23.45±0.40	4.93±0.14
27	10 (4.24)	27.37±0.26	2.74±0.08	24.91±0.90	5.21±0.18
28	6 (2.54)	28.38±0.36	2.94±0.08	25.48±0.26	5.41±0.17
29	16 (6.78)	29.37±0.25	2.99±0.12	26.88±0.36	5.59±0.19
30	16 (6.78)	30.33±0.38	3.04±0.09	27.61±1.02	5.78±0.14
31	8 (3.39)	31.36±0.27	3.10±0.13	28.79±0.34	5.98±0.19
32	24 (10.17)	32.46±0.28	3.24±0.06	29.30±0.58	6.41±0.16
33	22 (9.32)	33.29±0.29	3.38±0.07	30.03±0.50	6.44±0.16
34	36 (15.25)	34.33±0.62	3.45±0.12	30.77±0.57	6.75±0.16

GA: Gestational age, EGA: Estimated GA, FKL: Fetal kidney length, HC: Head circumference, FL: Femural length

Table 4: Correlation coefficient between the estimated gestational age and the fetal biometric parameters

	EGA (weeks)	
	Correlation coefficient (*r*)	*P*
HC (cm)	0.991	0.000*
FL (cm)	0.986	0.000*
FKL (cm)	0.982	0.000*

**P*<0.05 is significant. EGA: Estimated gestational age, HC: Head circumference, FL: Femur length, FKL: Fetal kidney length

kidney's anteroposterior diameter and transverse diameter are affected by conditions that impede fetal growth, the FKL is not and thus, is an accurate reflection of gestational age.[8,14] In this research, it was observed that the mean right FKL measured in mm was similar to the gestational age in weeks, as demonstrated in Table 3. At the mean EGA of 30.33 weeks, the mean FKL was 30.4 mm. This finding was corroborated by the report of Gayam *et al.* In their study, they found that FKL (r = 0.991, P = 0.000) was closer to LMP derived gestational age than other fetal growth parameters. They inferred that renal length in mm approximates the gestational age in weeks.[6] This was also supported by Chatterjee *et al.* in India, who reported that the mean FKL in millimeters equaled the gestational age in weeks from the 22nd to the 38th week.[12] This index study observed equality from the 30th week.

This research was done in pregnancies between the 20th and 34th week because it is expected that the measured value of HC and FL will be closely correlated to the fetal EGA during this period and become unreliable afterward.[2] However, the close correlation between EGA and FKL is expected to persist beyond the 34th week of gestation to about the 38th week of gestation just like it was propounded by Chatterjee *et al.*, who inferred that this feature of FKL means that it can be relied

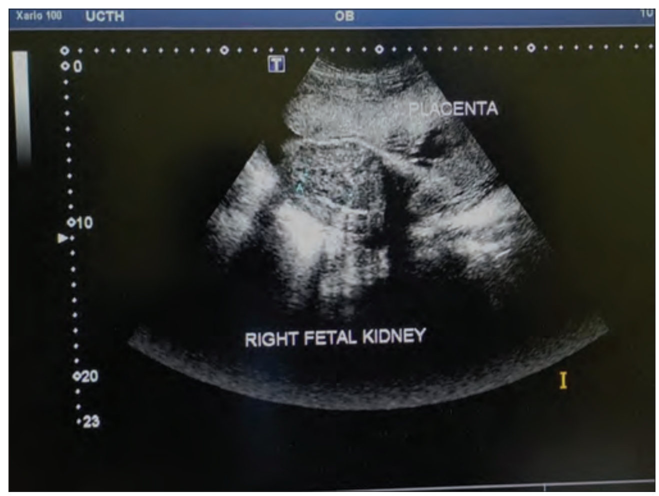

Figure 1: Two-dimensional B-mode image which shows how the right fetal kidney length is determined by placing a caliper on the superior and the inferior poles and measuring the distance between them (blue markers)

upon to decide the EGA of a pregnancy close to term or at term with unknown LMP.[12]

This study revealed that the positive correlation coefficient between EGA and FKL was significant, just like those of the standard routine biometry parameters [Table 4], although with a lower value (0.982). In a similar trend with the results of this research, Ugur *et al.* noticed that the correlation coefficient (r) between EGA and FKL (0.947) was lower than that of HC (0.974) and FL (0.967), although the P value was the same (0.0001).[17] In contrast, three research studies found a higher correlation coefficient between EGA and FKL, than with HC and FL. Das *et al.* in their study in India observed that the correlation coefficient (r) between EGA and FKL was higher (0.907) than that with the HC (0.836) and FL (0.853) with a P < 0.00001.[18] Furthermore, Gayam

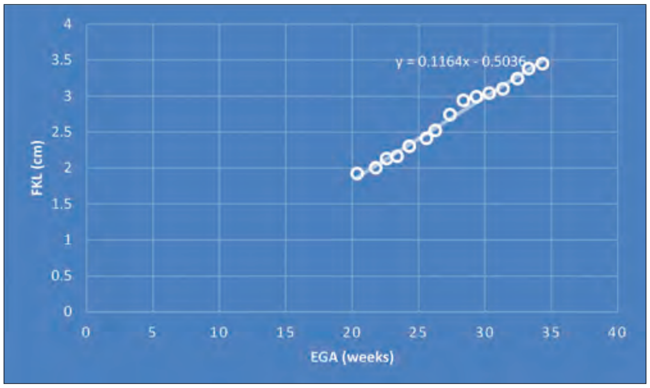

Figure 2: Scatterplot of fetal kidney length (dependent) and estimated gestational age

et al. in India noted that the correlation coefficient (r) between fetal EGA and FKL (0.991) was higher than the values of its correlation coefficient with HC (0.836) and FL (0.853) with $P = 0.000$ for all the parameters.[6] Ghaleb *et al*. in Egypt also observed a higher correlation coefficient (r) of 0.932 between EGA and the right FKL than that of HC (0.810) and FL (0.884) with a $P = 0.000$ for all the biometric parameters.[7] These researches which were done in different climes have demonstrated a significant positive relationship between the measured FKL and EGA, buttressing the feasibility of employing FKL as a parameter to determine fetal gestational age.

In evaluating the FKL in this research, it was noticed that in cases where it was difficult to completely visualize the fetal kidneys, shaking the maternal abdomen gently was useful in inducing marginal fetal movement which improved their visualization. The right fetal kidney was assessed in this study because both kidneys have been shown to have nearly the same length and similar correlation coefficient (r) with EGA (0.983).[15,16]

Some of the pregnant women who participated in this research were obese, which was a limiting factor for optimal visualization of the fetal kidneys and subsequent assessment of their lengths. Any factor that impairs the resolution of the renal margins during the sonographic evaluation will interfere with an accurate estimation of the FKL. Sometimes, the upper pole of the kidney is obscured by the twelfth rib's shadow. This is commonly encountered with the left kidney, hence the choice of using the right kidney.

Conclusion

FKL is a viable biometric parameter for determining the gestational age of pregnancy between 20 and 34 weeks. It can be used as an alternative sole tool of gestational age assessment between 20 and 34 weeks, especially when the HC, AC, BPD, and FL are difficult to access or compromised. The length of the fetal kidney in mm, approach equality to the EGA (weeks), between the thirtieth and thirty fourth week of pregnancy.

Recommendations

A multi-center study in different regions of the country should be conducted in healthy pregnancies between 20 and 40 weeks to establish a reliable kidney length nomogram. In addition, the FKL should be tested beyond 34 weeks as a sole index to determine the gestational age in compromised pregnancies such as intra-uterine growth restriction and oligohydramnios, macrosomia, and dysplasias such as achondroplasia.

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Conflicts of interest

There are no conflicts of interest.

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