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Original article

Ultrasonographic estimation of fetal gestational age by fetal kidney length

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KEYWORDS

Fetal kidney length, Biparietal diameter, Femur length, Gestational age.

ABSTRACT

Introduction: Fetal kidney length vs biparietal diameter (BPD) and femur length (FL) were comparatively evaluated and the role of fetal kidney length in estimating gestational age was determined in the second and third trimesters. *Materials and methods*: The study was carried out on 199 women with singleton uncomplicated pregnancies attending the outdoor patient department (OPD) for routine ultrasound fetal biometry. Fetal kidney length was measured biweekly, between 18 weeks and 38 weeks of gestation. Linear regression models for estimation of gestational age were derived from biometric indices (BPD and FL) and kidney length. *Result:* The earliest age at which fetal kidney could be seen sonographically was the 18th week of gestation with the mean kidney length of 12 ± 1.31 mm. The mean sonographic kidney length at the 38th week of gestation was 40.4 ± 1.71 mm, indicating that the mean fetal kidney length increases as pregnancy progresses from 18 weeks to 38 weeks of gestation. *Conclusion*: The best linear regression model for estimating fetal gestational age is femur length, kidney length, and biparietal diameter in that order, with standard error of ±3.85 days, ±8.04 days, and ±8.75 days, respectively.

1. Introduction

The knowledge of accurate estimation of gestational age for an obstetrician is first and foremost to date the pregnancy as early as possible during antenatal period for the management of all pregnancies. Failure can result in iatrogenic prematurity or post maturity, both of which are associated with increased perinatal mortality and morbidity. Initially the dating of pregnancy was based on the first day of last menstrual period (LMP) in a regular 28-day menstrual cycle. But this method for dating the pregnancy is failing in those women who do not exactly recall their menstrual history. Since the introduction of diagnostic ultrasound, more reliable methods to date the pregnancy have been developed. In the first term, these are gestational sac diameter and volume and crown-rump length (CRL) measurements. In the second trimester, the most commonly used biometric indices for dating pregnancies are biparietal diameter (BPD) and femur length (FL)[1] and other used parameters are transverse cerebellar diameter,[2] scapular measurement,[3] fetal kidney length,[4] and fetal renal volume.[5]

Fetal kidney is easy to identify and measure in the late second and in the third trimesters and there is a strong correlation between gestational age and fetal kidney length.[6]

Hence, the present study is undertaken to measure fetal kidney length for estimation of gestational age and compare it with other biometric indices such as BPD and FL.

2. Materials and methods

The study was carried out, after obtaining informed consent, on 199 women with singleton uncomplicated pregnancies attending the outdoor patient department (OPD) for routine

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ultrasound fetal biometry, in the Department of Radiodiagnosis, LLRM Medical College, and associated SVBP Hospital Meerut. This study included only those uncomplicated pregnant women having single live normal fetus and those women who had multiple pregnancies and suffered from eclampsia, pre-eclampsia, and chronic hypertension. Diabetes mellitus and intrauterine growth retardation were excluded from the study.

We measured the kidney length (KL) by using a Madison S A 8000 S E ultrasonographic machine with curvilinear probe 3.5–5 MHz. The maximum renal length was measured from the upper to lower pole of the kidney in a longitudinal section of the fetus in the sagittal plane. We measured both kidneys per fetus in the construction of the KL charts in the sagittal plane. The fetal kidneys appear ultrasonically as a sonolucent halo of tissues surrounding the somewhat more echogenic pyelocalyceal sinus. The kidneys are difficult to identify prior to 17 weeks of gestation. The standard methods of obtaining the BPD and FL were employed. After confirming the lie, axial sections were obtained perpendicular to the spine, adjusting the position of patient, tilting the scanning arm for the best results. A series of axial scans through the kidneys were then performed at 3 mm intervals. To obtain a coronal or sagittal view, the scanning arm was turned 90° to the plane of the axial scans. Statistical analysis was done using a linear regression equation.

3. Result

In our study, the earliest age at which fetal kidney could be seen sonographically was found to be the 18th week of gestation and the mean KL is 12 ±1.31 mm. The mean sonographic KL at the 24th week of gestation is 21.60 ± 1.70 mm (Fig. 1) and at the 38th week of gestation is 40.4 ± 1.71 mm (Fig. 2). Table 1 shows an increase of mean fetal kidney length between 18 weeks and 38 weeks of gestation.

Table 1 – Mean kidney length (number of cases = 199).

S. No.	Gestational age (weeks)	Number of cases	Number of kidneys	Mean kidney length (mm ± SD)
1	18	06	12	12.00 ± 1.31
2	20	15	30	15.3 0 ± 2.10
3	22	17	34	19.30 ± 1.74
4	24	15	30	21.60 ± 1.70
5	26	19	38	26.30 ± 1.14
6	28	13	26	29.80 ± 2.24
7	30	21	42	34.30 ± 1.24
8	32	28	56	36.20 ± .70
9	34	36	72	37.20 ± 1.04
10	36	23	46	38.90 ± 1.53
11	38	06	12	40.40 ± 1.71

SD: Standard deviation.

Table 2 shows the predicted values of various parameters (BPD, FL, and KL).

There was a significant correlation between gestational age (weeks) and mean fetal kidney length (mm), $r^2 = 0.98$ ($p < 0.0001$). The most accurate was femur length with standard error of prediction of ±3.85 days. The accuracy of KL and BPD is ±8.4 days and ±8.74 days, respectively. Other values of these parameters are given in Table 2.

4. Discussion

We compared the mean fetal kidney length of our study with that of Konje et al[7] and Kansaria and Parulekar.[6] The data of the present study for mean fetal kidney length increase as pregnancy progresses from 18 weeks to 38 weeks of gestation (12.0 ± 1.3 mm, 15.3 ± 2.1 mm, 19.3 ±1.7 mm, 21.6 ± 1.7 mm, 26.3 ± 1.1 mm, 29.8 ± 2.2 mm, 34.3 ± 1.2 mm, 36.2 ± .7 mm, 37.2 ± 1.0 mm, 38.9 ± 1.5 mm, and 40.4 ± 1.7 mm at 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, and 38 weeks of gestation, respectively).

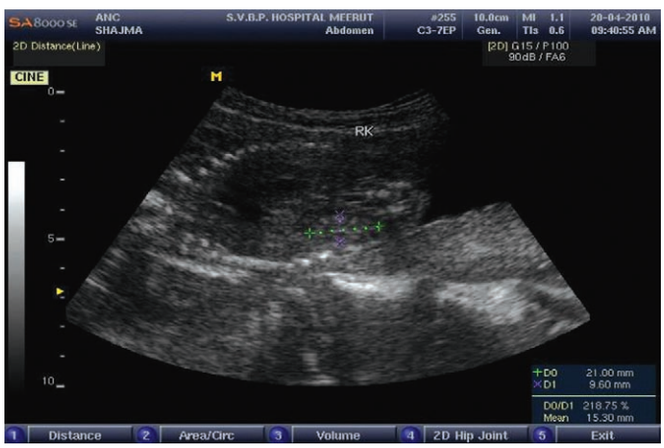

Fig. 1 – Ultrasonogram showing measurement of right fetal kidney length of 21.00 mm in sagittal plane at 24 weeks of gestation.

Fig. 2 – Ultrasonogram showing measurement of right kidney length of 43.50 mm in sagittal plane at 38 weeks of gestation.

Table 2 – Predicted values of various parameters (independent variables such as biparietal diameter, femur length, and kidney length and dependent variables such as gestational age in weeks).

Parameters	Intercept (a)		Slope (b)		p value (significance)		95% confidence interval				R square	SEp
							Intercept (a)		Slope (b)			
	Estimate	Standard error	Estimate	Standard error	Intercept (a)	Slope (b)	Lower bond	Upper bond	Lower bond	Upper bond		
1. BPD	1.455	1.647	0.377	0.023	0.400	<0.0001	–2.271	5.181	0.326	0.429	0.968	8.75
2. FL	6.087	0.595	0.418	0.011	<0.0001	<0.0001	4.740	7.434	0.393	0.442	0.994	3.85
3. KL	9.557	1.126	0.652	0.038	<0.0001	<0.0001	7.009	12.104	0.567	0.737	0.985	8.4

BPD: Biparietal diameter; FL: Femur length; KL: Kidney length.
1. Independent variables (BPD, FL, and KL).
2. Dependent variables i.e., gestational age in weeks.
3. SEp = Standard error of prediction.

Table 3– Linear regression equation comparison of kidney length and other fetal biometric indices between the present study and that of Konje et al[7] and Kansaria and Parulekar.[6]

Parameters	Study	Intercept		Slope		p value	r^2
		Estimate	Standard error	Estimate	Standard error		
KL	Present study	9.557	1.126	.652	.038	<0.0001	97.1
	Konje et al[7]	3.821	0.38	0.858	0.012	<0.0001	90.0
	Kansaria and Parulekar[6]	2.964	0.42	0.832	0.012	<0.0001	97.67
FL	Present study	6.087	0.595	.418	0.011	<0.0001	99.4
	Konje et al[7]	5.00	0.348	0.449	0.005	<0.0001	89
	Kansaria and Parulekar[6]	3.084	0.52	0.411	0.006	<0.0001	94.84
BPD	Present study	1.455	1.647	.377	0.023	<0.0001	96.8
	Konje et al[7]	0.808	0.447	0.388	0.005	<0.0001	88
	Kansaria and Parulekar[6]	0.741	0.447	0.388	0.005	<0.0001	90.91

KL: Kidney length; FL: Femur length; BPD: Biparietal diameter.

The readings of fetal kidney length reported by Konje et al[7] between 24 weeks and 38 weeks of gestation at two weekly intervals are 24.2 ± 1.2, 26.3 ± 1.9, 29 ± 2.2, 30.9 ± 3.2, 33.2 ± 4.5, 35.0 ± 3.6, 38.2 ± 4.2, and 40.1 ± 2.4 and that of Kansaria and Parulekar[6] are 23.87 ± 1.17, 25.23 ± 1.18, 26.98 ± 1.06, 29.03 ± 1.32, 30.8 ± 1.53, 32.51 ± 1.38, 34.26 ± 1.41, 36.25 ± 1.70, respectively.

The fetal kidney lengths at different gestational ages are higher than those reported by Konje et al[7] and Kansaria and Parulekar[6] from the 24th week of gestation to the 38th week of gestation except at 24, 26, and 38 weeks. At 24 weeks of gestation, our reading is lower than those reported by Konje et al[7] and Kansaria and Parulekar[6] but at 26 and 38 weeks of gestation, our values are near about similar to those reported by Konje et al.[7] Our values of mean fetal kidney length are higher than those reported by Yusuf et al[8] from 32 weeks of gestation to 38 weeks of gestation (our readings are 36.2 mm, 37.2 mm, 38.9 mm, and 40.4 mm and readings reported by Yusuf et al[8] are 32.0 mm, 34.2 mm, 35.9 mm, and 37.0 mm at 32 weeks, 34 weeks, 36 weeks, and 38 weeks of gestation, respectively). The values in our study are lower or higher as discussed above because there are significant racial and socioeconomic differences between individuals of the present study and those of studies done by Konje et al,[7] Kansaria and Parulekar,[6] and Yusuf et al.[8]

The differences in the readings may also be attributed to the number of operators (multiple vs two skilled operators vs one skilled operator), type of study (cross-sectional vs longitudinal), estimation of gestational age (rounded off vs exact), and quality of ultrasound machine (older vs newer).

In the present study, all sonographic measurements were performed by a single skilled and experienced sonologist; it was a random study, the ultrasound machine used was new, and the patients included in the study were from Western Uttar Pradesh.

Kidney length predicted gestational age with better precision than the model with biometric index of BPD. This provides an obvious advantage where BPD cannot be accurately measured because either the fetal head is too low or correct plane for measurement cannot be obtained. In these circumstances, KL can be used on its own to estimate gestational age. The linear equations derived from the present study have been compared with the individual variable separately with the study done by Konje et al,[7] and Kansaria and Parulekar[6] (Table 3). Fetal kidney length varied with a standard error (SE) of 10.29 days by Konje et al,[7] 9.17 days by Kansaria and Parulekar,[6] and 8.4 days by this study. In the present study, we have correlated fetal kidney length with gestational age that is calculated from standard measured parameters i.e., BPD and FL, and the study demonstrated that the fetal kidney length is correlated with gestational age significantly. Cohen et al in a sonographic study of 397 obstetric patients demonstrated that the gestational age is related to the KL.[9] Kaul et al has suggested that the fetal

kidney length is the most accurate single parameter for estimating gestational age.[10] Measurements of fetal kidney length showed good correlation with gestational age with correlation coefficient 0.985 and $p < 0.0001$. Fetal kidney length increases fortnightly, approximately at the rate of 3.18 mm.

Fetal kidney length measurement can be introduced as a measure for estimating gestational age where BPD and FL are unreliable.

5. Conclusion

Fetal kidney length can be used as an investigational tool in the determination of gestational age in the late second and third trimesters of pregnancy. Fetal kidney length is not affected by the discrepancy of late trimester or by fetal growth retardation. The best linear regression model for estimating fetal gestational age is FL, KL, and BPD in that order, with standard error of ± 3.85 days, ± 8.04 days, and ± 8.75 days, respectively

In rural Indian women, the illiteracy rate is higher than that in urban women. Thus, mainly rural pregnant women do not give their proper menstrual history. Thus, in these cases fetal kidney length can be used as a tool for estimating fetal gestational age in the second and third trimesters and it can be applicable in routine practice in general population.

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