Estimation of Gestational Age by Using Fetal Kidney Length and Transcerebellar Diameter in Comparison with Other Biometric Indices

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ABSTRACT

Background: The knowledge of accurate estimation of gestational age (GA) for an obstetrician is first and foremost to date the pregnancy as early as possible during the antenatal period for proper management of all the pregnancies. Ultrasound parameters like BPD, HC, AC and FL in second and third trimesters are not very reliable for dating the pregnancy. Fetal kidney length (FKL) and transcerebellar diameter (TCD) have been studied and shown to strongly correlate with the gestational age.

Materials and methods: A prospective observational study was conducted on 600 women with normal singleton pregnancies. Fetal kidney length and transcerebellar diameter were measured using Voluson E8 (Wipro GE) ultrasound machine. Statistical analysis was done using tests of correlation and simple linear regression. All analysis was done by using SSPS statistics 24.0.

Results: The result indicates that the fetal kidney length and transcerebellar diameter in the present study correlated well with the assigned gestational age. A positive linear relationship of gestational age with fetal kidney length and transcerebellar diameter was found. Correlation of gestational age with fetal kidney length and transcerebellar diameter was 0.875 and 0.975 respectively.

Conclusion: The present study reveals that fetal kidney length and transcerebellar diameter can be used as parameters in estimating gestational age, especially in later trimesters, where biometric indices may not be much reliable.

Keywords: Fetal kidney length, Gestational age, Transcerebellar diameter.

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INTRODUCTION

The commonest problem that is often faced by an obstetrician is the assessment of fetal maturity for either prolonging the pregnancy or terminating it for complications, such as, fetal distress, pregnancy-induced hypertension, and Rh incompatibility diseases.¹ The knowledge of accurate estimation of gestational age (GA) for an obstetrician very essential to date the pregnancy during the antenatal period for proper management of all the pregnancies.² Accurate GA assessment is pivotal to quality maternity care, e.g., diagnosis of growth disorders and timing of delivery. Failure can result in iatrogenic prematurity or postmaturity, both of which are related to increased perinatal morbidity and mortality.³

Ultrasound fetal biometry is the most widespread method used to establish GA.⁴ The exemplary safety record of diagnostic ultrasonography is probably an important reason that it has become so widely used.⁵ Currently, the various parameters which are being used include the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL).^{6,7} However, as the pregnancy advances these parameters become increasingly unreliable in the accurate prediction of GA.⁴ Sonographic estimation of GA by using fetal biometric parameters such as BPD, HC, FL, and AC to perform an important role in the further management of pregnancy. There are some limitations with these parameters, such as, conditions altering the skull shape makes BPD unreliable after 26 weeks of gestation. Femur length is shortened in patients with achondroplasia making it an unreliable parameter in estimating GA.⁸

Conditions, such as, multiple gestations, oligohydramnios, polyhydramnios, breech presentation and intrauterine growth restriction (IUGR) can affect the BPD, HC, FL, and AC measurements.

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With advancing pregnancy, these parameters become progressively unreliable in the estimation of GA. Therefore, accurate estimation of GA in the second and third trimesters remains problematic. There are various non-traditional sonographic parameters for the estimation of GA that are being studied. These include transverse cerebellar diameter, fetal kidney length (KL), fetal foot length, placental grading, and amniotic fluid volume.⁹

The fetal kidney is easy to identify and measure, in the second and the third trimesters when BPD, HC, FL, and AC become gradually unreliable in the estimation of GA and there is a strong correlation between GA and fetal kidney length (FKL) but has not been studied broadly as a biometric index for GA estimation.²

The cerebellum is located in the posterior cranial fossa is surrounded by petrous ridges and the occipital bone which allows

it to withstand the deformation caused by extrinsic pressure.⁸ The transcerebellar diameter (TCD) grows rapidly with a linear relationship pattern correlating with GA from the second trimester and is a consistent ultrasound parameter for GA estimation by the end of the second trimester.¹⁰

The purpose of the current study is to evaluate the accuracy and reproducibility of KL and transverse cerebellar diameter in assessing GA in normal pregnancies between 19 and 39 weeks. In addition, we compared the accuracy of this method with that using the BPD, head and ACs, and FL.

MATERIALS AND METHODS

This diagnostic study was carried out on six hundred antenatal patients in GA of 19–39 weeks by ultrasonography.

Patients with a clinically normal singleton pregnancy, undergoing routine antenatal ultrasonography screening between 19 weeks and 39 weeks, and attending the antenatal clinic were included in the study. Ultrasound was performed on Voluson E8 (Wipro GE).

Inclusion Criteria

Normal singleton pregnancies of 19–39 weeks who were sure about their last menstrual period or have first-trimester ultrasound confirmation of GA by means of crown-rump length measurement.

Women consenting to participate in the study.

Exclusion Criteria

Women who are not sure about their last menstrual period.
Multiple gestations.
Congenital malformations.

Methodology of Measurement of Various Parameters

In each patient, BPD, HC, AC, FL, KL, and TCD were measured.

AC: Measurement is taken on a transverse plane at the level of the stomach and intrahepatic portion of the umbilical vein.

BPD: Measurement is taken from transaxial sonograms of the fetal head at the level of paired thalami and cavum septum pellucidum. The BPD was measured from the outer edge of the cranium nearest the transducer to the inner edge of the cranium farthest from the transducer.

HC: Measurements were taken in the same plane as that of BPD. Measured by tracing along the outer edge of cranium using the ellipse method.

FL: Measurement was taken from the greater trochanter to the lateral condyle.

FKL: The fetus was scanned in the transverse plane until the kidneys will be visualized just below the stomach. The probe was then rotated through 90° to outline the longitudinal axis of the kidneys. Markers were placed on the image of the renal capsule to measure FKL (Figs 1 and 2).

TCD: The cerebellar view was obtained by rotating the transducer in the axial plane centered on the thalamus to show the cerebellar hemispheres. This view shows cerebellum, cisterna magna, and cavum septum pellucidum. The cerebellum characteristically appears as two lobules on either side of the midline in the posterior cranial fossa. The widest diameter of the cerebellum was measured (Fig. 3).

From the above-measured parameters, GA and effective fetal weight were computed by the ultrasound machine based on Hadlock tables by using regression equations from a combination of measurements (computation software package).

Statistical analysis was done using a statistical package for social science (SPSS 24). Pearson's correlation and regression coefficient were calculated between GA and FKL, GA, and TCD as well as GA and other fetal biometric indices (Figs 4 and 5).

RESULTS

Fetal kidney length and TCD were measured in a cross-sectional population of 600 pregnant women at different GAs ranging from

Fig. 1: Kidneys are identified, moving the probe caudally in the transverse section just below the level for abdominal circumference measurement. Once kidneys are located, the probe is rotated longitudinally till the full length of the kidney was identified for its length calculation. The fetal kidneys were measured from outer to outer margin. Here, the mean fetal kidney length was calculated as 3.53 cm and the Hadlock-based average gestational age was 36 weeks 3 days

Fig. 2: The mean fetal kidney length was calculated as 3.615 cm and Hadlock-based average gestational age was 35 weeks 4 days

Fig. 3: The cerebellar view was obtained by rotating the transducer in the axial plane centered on the thalamus to show the cerebellar hemispheres. The widest diameter of the cerebellum was measured. Here, the transcerebellar diameter was calculated as 2.20 cm and the Hadlock-based average gestational age was 21 weeks 5 days

Fig. 4: Scatter diagram showing the correlation and regression analysis of the fetal kidney length with gestational age

Fig. 5: Scatter diagram showing the correlation and regression analysis of the transcerebellar diameter with gestational age

19 to 39 weeks of gestation. Both kidneys and TCD were measured in each patient and their mean and standard deviation were calculated. Tables 1 and 2 show an increase of mean FKL and TCD according to GA at various weeks between 19 and 39 weeks. There was a significant correlation between GA (weeks), mean FKL, and TCD (Tables 1 and 2).

Table 3 shows the association between fetal measurements and GA. The correlation for GA vs HC, TCD, and FL was almost similar (r : 0.988, 0.975, and 0.973, respectively). The correlation was best for GA vs HC (r : 0.988). The correlation for GA vs FKL was 0.875 (Table 3).

Table 4 shows the association between fetal measurements with TCD. The correlation was best for TCD vs HC (r : 0.966) and least for TCD vs AC (r : 0.940). Table 5 shows the association between fetal measurements with FKL. The correlation was best for FKL vs HC (r : 0.870) and least for FKL vs AC (r : 0.842). All the correlations were statistically significant (Tables 4 and 5).

DISCUSSION

Accurate gestational dating is of utmost importance and the basis for the management of all pregnancies. Methods to date

Table 1: Mean fetal kidney length with standard variation at various weeks between 19 and 39 weeks

Weeks	N	Mean	Std. deviation	95% confidence interval for mean	
				Lower bound	Upper bound
19.00	4	2.15	0.01	2.14	2.16
20.00	64	2.12	0.19	2.07	2.17
21.00	20	2.23	0.13	2.17	2.28
22.00	16	2.46	0.17	2.37	2.56
23.00	8	2.45	0.15	2.33	2.57
24.00	4	2.62	0.00	2.62	2.62
25.00	8	2.89	0.30	2.64	3.14
26.00	8	2.93	0.52	2.49	3.37
27.00	8	3.09	0.28	2.85	3.33
28.00	12	3.09	0.07	3.05	3.14
29.00	32	3.17	0.23	3.08	3.25
30.00	16	3.43	0.30	3.27	3.59
31.00	56	3.32	0.27	3.25	3.40
32.00	36	3.44	0.50	3.27	3.61
33.00	44	3.56	0.30	3.46	3.65
34.00	68	3.74	0.42	3.64	3.84
35.00	76	3.79	0.35	3.70	3.87
36.00	56	3.98	0.43	3.86	4.09
37.00	36	4.07	0.49	3.91	4.24
38.00	20	4.01	0.12	3.95	4.06
39.00	8	3.87	0.19	3.71	4.03
Total	600	3.35	0.71	3.30	3.41

Table 2: Transcerebellar diameter with standard variation at various weeks between 19 and 39 weeks

Weeks	N	Mean	Std. deviation	95% confidence interval for mean	
				Lower bound	Upper bound
19.00	4	2.03	0.02	2.01	2.05
20.00	64	2.11	0.05	2.10	2.12
21.00	20	2.29	0.07	2.25	2.32
22.00	16	2.38	0.06	2.35	2.41
23.00	8	2.59	0.15	2.46	2.72
24.00	4	2.60	0.00	2.60	2.60
25.00	8	2.93	0.06	2.88	2.97
26.00	8	3.31	0.25	3.10	3.52
27.00	8	3.16	0.12	3.05	3.26
28.00	12	3.37	0.29	3.18	3.55
29.00	32	3.61	0.14	3.56	3.66
30.00	16	3.61	0.17	3.52	3.70
31.00	56	4.17	0.31	4.09	4.26
32.00	36	4.27	0.27	4.18	4.37
33.00	44	4.55	0.36	4.44	4.66
34.00	68	4.67	0.25	4.61	4.73
35.00	76	4.81	0.22	4.76	4.86
36.00	56	4.98	0.21	4.92	5.03
37.00	36	5.10	0.17	5.04	5.16
38.00	20	5.27	0.26	5.15	5.40
39.00	8	5.45	0.11	5.36	5.54
Total	600	4.05	1.06	3.96	4.13

Table 3: Correlation coefficient of GA with BPD, HC, FL AC, TCD, and FKL

Pair	Pearson correlation	p value
GA/BPD	0.967	0.001
GA/HC	0.988	0.001
GA/FL	0.973	0.001
GA/AC	0.968	0.001
GA/TCD	0.975	0.001
GA/FKL	0.875	0.001

Table 4: Correlation coefficient of TCD with BPD, HC, FL, and AC

Pair	Pearson correlation	p value
TCD/BPD	0.950	0.001
TCD/HC	0.966	0.001
TCD/FL	0.947	0.001
TCD/AC	0.940	0.001

Table 5: Correlation coefficient of FKL with BPD, HC, FL, and AC

Pair	Pearson correlation	p value
FKL/BPD	0.869	0.001
FKL/HC	0.870	0.001
FKL/FL	0.852	0.001
FKL/AC	0.842	0.001

pregnancies should be very easy, simple, uncomplicated, and straightforward, irrespective of the GA. Accurate and easily reproducible sonographic fetal biometric parameters for GA dating are clinically very essential for the ideal management of pregnancies. This is vitally true in determining the timing of a variety of gestational tests, assessing the adequacy of growth, and timing of delivery for the optimal obstetric outcome.¹¹ This prospective study of 600 healthy women with uncomplicated pregnancy suggests a correlation between GA, FKL, and TCD.

In the present study, a linear relationship has been established in the second and third trimesters and has been correlating well with clinical GA. In the present study, FKL and TCD correlate well with GA with a correlation coefficient of 0.875 and 0.975, respectively.

Although kidney size may be disturbed by growth variations, these predominately affect only anterior–posterior and transverse diameters. The KL, however, remains largely unaffected in small for GA fetus.¹² Duval et al.¹³ encountered difficulty in the imaging of kidney in breech and vertex presentation with the back facing laterally or posteriorly. There was no such problem encountered in our present study in imaging and measurement of KL. The fetal kidney appearance changes with advancing GA. With advancing pregnancy, an increased echogenicity from increasing perinephric fat makes them more visible by allowing easier separation of the kidney from surrounding soft tissue.¹⁴ Technical error or maternal obesity may sometimes result in poor scans and prevent identification of fetal kidneys, especially during early gestation where the fetal adrenal and renal parenchyma have identical homogeneous patterns and closer to term this point is further obscured by the echogenic nature of lower ribs.^{15,16} This probably explains the slightly different results in different studies.¹⁷

The present study showed that FKL increases linearly with GA from 2.15 ± 0.01 cm at 19 weeks to 3.87 ± 0.19 cm at 39 weeks.

Similarly, TCD increases linearly with GA from 2.03 ± 0.02 cm at 19 weeks to 5.45 ± 0.11 cm at 39 weeks. The values for the FKL at different GAs were slightly higher than the study of those reported by Kansaria and Parulekar,¹⁸ Kumar et al.,² Peter et al.,⁹ and Bharatnur et al.¹⁹ The values of FKL at different GAs were similar to that of Konje et al. (4.01 ± 0.24 cm at 38 weeks).³

Transcerebellar diameter serves as a unique parameter for estimation of GA and is a standard against which deviation in other parameters may be compared.²⁰ From the second trimester, it grows rapidly with a linear relationship pattern correlating with GA.^{21,22} In the present study, a good correlation between TCD and GA was found in normal pregnancies ($R^2 = 0.975$, p value <0.001). Also, a statistically significant correlation was found between TCD and BPD ($R^2 = 0.950$, p value <0.001) and between TCD and HC ($R^2 = 0.966$, p value <0.001). Similar observations were made in a study done by Goldstein et al. on 371 normal pregnant women, with GAs ranging from 13 to 40 weeks. They found curvilinear relationships between the TCD with the GA ($R^2 = 0.948$; $p = 0.001$), the BPD ($R^2 = 0.956$; $p = 0.001$), and the HC ($R^2 = 0.969$; $p = 0.001$).²³ Thus, it is concluded that throughout pregnancy normative cerebellar measurements allow for estimation of GA that is independent of the shape of the fetal head.^{23,24} Our results concur with the observations made in a study by Bansal et al. on 650 cases with a GA of 14–40 weeks. They found the TCD to be equivalent to the gestation age of a fetus, with the Karl Pearson correlation coefficient between GA and TCD being 0.972305 and p value to be <0.001 which was highly significant.²⁵

The FKL and TCD in the present study correlated well with the assigned GA. This provides an obvious advantage where there is difficulty in measuring BPD, HC due to engaged head or small AC due to IUGR. In such circumstances, FKL and TCD can be used on its own to estimate GA accurately.

The present study hence validates the recommendation that FKL and TCD can be used as an important sonographic parameter for accurate prediction of fetal gestation age. The relationship of fetal kidney growth and TCD with GA is statistically significant.

LIMITATION

Fetal kidney length and TCD are not routinely measured in fetal biometry. So, this study was done to demonstrate the accuracy of GA measured by FKL and TCD with that of Hadlock-based average GA. Further studies with a large sample size may be required to corroborate our findings and to establish FKL and TCD as accurate and more reliable parameters in the estimation of GA in second and third trimesters.

CONCLUSION

Fetal kidney length and TCD increase with an increase in GA and show an excellent correlation coefficient which suggests good agreement and reproducibility of measurements and is not affected by the discrepancy of the late trimester. This study concludes that FKL and TCD show a strong correlation with fetal GA, with a steady growth rate throughout pregnancy.

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