Research Article

Estimation of gestational age using foetal kidney length during second and third trimester in south Indian population**Kalpana Ramachandran¹, Arunthathy Gnaneshwar², Robert Dinesh Kumar³, Parvathavarthine C. R.⁴, Sri Santhana Krishnan V⁵**¹Professor & Head, Department of Anatomy, Sri Ramachandra Medical College & Research Institute, Sri Ramachandra Institute of Higher Education & Research (SRIHER), Porur, Chennai 600116, India²Associate Professor, Department of Radio diagnosis, ³Assistant Professor, ⁴Associate Professor, Department of Anatomy, ⁵Assistant Professor, Department of Community Medicine
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Corresponding author: **Arunthathy Gnaneshwar**. Email: kalpanasriram1@gmail.com**ABSTRACT****Introduction and Aim:** Gestational age assessment in women with indeterminate last menstrual period has always remained an enigma. Though multiple parameters have been found useful in providing an indirect age assessment, various studies have now shown that the ultrasonographic measurement of foetal kidney length during the second and third trimester of pregnancy is a viable alternative in foetal age assessment.**Methods:** This prospective study was conducted among the antenatal women with singleton uncomplicated pregnancy during 18 to 40 weeks of gestation attending the outpatient department for routine ultrasound foetal biometry in a tertiary care referral institution in South India, during January 2019 to June 2019. A total of hundred and thirty-five antenatal mothers were included in this study. Data entry was done in Microsoft Excel and data analysis was done using Statistical Package for Social Sciences (SPSS).**Results:** There was a strong positive correlation between GA and MKL. Regression model (Model 1) for Mean kidney length showed significant correlation and regression models (Model 2) for MKL and routine foetal biometric parameters like biparietal diameter, femur length and abdominal circumference were found to be significantly correlated.**Conclusion:** Mean foetal kidney length can alone predict gestational age and by combining it with the other biometric indices to give a better estimation of gestational age.**Keywords:** Gestational age; foetal kidney length; ultrasound; antenatal; pregnancy**INTRODUCTION**

An accurate estimation of the foetal age is necessary to make an assessment of the exact date of delivery and to follow up the growth of various foetal organs. Indirectly, it helps in the prevention of prenatal and postnatal morbidities to the newborn child. In many developing countries, where the female education is below the expected standards, it is not uncommon to encounter antenatal mothers being ignorant about their last menstrual period (LMP). Calculating the expected date of delivery would be so difficult in such circumstances. Studies conducted by various authors reported that up to 30% of female were unsure of their LMP (1, 2). If exact LMP is not known, calculation of an approximate expected date of delivery (EDD) would be a real challenge for the treating obstetricians. To overcome this pitfall, measurements of various foetal body parts (foetal biometry) is practised.

Though various parameters indicate the gestational age, till date, there is no consensus about one definite parameter that can assess the foetal age accurately by

ultrasonography. To circumvent this problem, various parameters have been used to obtain an indirect assessment of the foetal age. Biparietal diameter, abdominal circumference, lengths of long bones like femur and humerus are the few parameters helpful in assessing the gestational age. The length of the foetal kidney is a useful dimension that is established in recent studies to correlate with the gestational age (3, 4). There have been multiple studies in the past that have observed the clinical usefulness of foetal kidney length (FKL) in gestational age assessment, especially between the 24th to 38th weeks (5). Femur length and bi-parietal diameter have more significance before 36 weeks while head circumference and femur length are the more reliable parameters beyond 36 weeks of gestation (6). Length of the femur is also identified to be a better parameter in comparison to the bi-parietal diameter for age determination of foetus in the third trimester (7). The ethnicity of the individual also is observed to exert a significant influence on foetal biometry (8, 9).

FKL measurements in the past were done to diagnose foetal renal malformation. Later on, they were done to assess the correlation with the gestational age (10). The significant advantage of FKL measurement is that the value is not altered by intrauterine foetal growth retardation (11). FKL has been observed to show a steady growth of 1.7 mm every 15 days during entire pregnancy even in foetal growth retardation (12).

The main objectives of this study are to assess whether the foetal kidney length using ultrasonography in the second and third trimester of pregnancy correlates well with the gestational age and to compare its significance with other biometric indices.

Methodology

This prospective study was conducted among the antenatal women with singleton uncomplicated pregnancy during 18 to 40 weeks of gestation attending the outpatient department for routine ultrasound foetal biometry. This study was done in the Department of Radiology of a tertiary care medical college hospital in south India, from January 2019 to June 2019. Institutional review board permission and clearance from the ethics committee were obtained before the start of the study. All consecutive antenatal mothers with known LMP and correlating dating scan were included in this study. Routine ultrasound foetal biometric measurements were studied during this study period. Those women who are having multiple pregnancies and suffering from eclampsia, pre-eclampsia and chronic hypertension, diabetes mellitus and IUGR were excluded from this study. Those kidneys with antenatal hydronephrosis or with an anteroposterior renal pelvic diameter of more than 5 mm were also excluded from our study. Patients in whom there was difficulty in identifying the upper pole of the kidney were also excluded. Multiple pregnancies and antenatal women who were unaware of their LMP were also excluded. A detailed history including their LMP was taken and the actual gestational age and the expected date of delivery were calculated using

Naegle's formula (Expected Date of Delivery (EDD) = LMP + 7 days– 3 months + 1 year).

All foetal kidney measurements were taken in the para-sagittal plane. The upper and lower poles were well delineated. The longest pole to pole length was measured and marked as the foetal kidney length. The right and left kidney lengths were individually measured and the mean values were recorded to reduce the operator-dependent error in foetal kidney measurements. Patient anonymity was maintained throughout the study and individual patients' details were kept confidential. The study was approved by the Institutional Ethics Committee.

The maximum foetal kidney length on both the sides will be measured from upper to lower pole of the kidney in a longitudinal section of the foetus in the sagittal plane. The biparietal diameter (BPD), femur length (FL), abdomen circumference (AC) and head circumference (HC) was also measured by Hadlock method. All the data were statistically analysed and the foetal kidney length was compared with biparietal diameter, femur length, abdomen circumference and head circumference using the linear regression equation.

Statistical analysis

The data obtained were tabulated and analyzed by calculating the mean, standard deviation, standard error. Data entry was done in Microsoft Excel and data analysis was done using Statistical Package for Social Sciences (SPSS) version 17. Statistical tests like descriptive statistics, Pearson correlation and regression were used appropriately. P-value <0.05 was considered as significant.

RESULTS

A total of 135 pregnant women and 270 foetal kidneys were studied. The majority of the foetal kidneys (44 kidneys) were seen through ultrasonography during 20-22 weeks of gestation. Fig. 1 illustrates the ultrasonographic appearance of the foetal kidneys.

Fig. 1: Ultrasonographic appearance of the foetal kidney.

Table 1: Mean kidney length (n=135)

Gestational age in weeks	Frequency	Right kidney length (mm)	Left kidney length (mm)	Mean kidney length (mm)
18.0	02	14.5±2.1	16.0±2.8	15.2±2.4
18.1-20	07	18.5±1.6	19.2±1.1	18.8±1.2
20.1-22	24	21.2±2.9	21.6±2.6	21.4±2.7
22.1-24	11	23.3±3.0	24.2±3.7	23.8±3.3
24.1-26	02	2.80±0.98	2.70±0.98	2.75±0.98
26.1-28	09	27.5±2.7	2.84±1.7	27.9±2.0
28.1-30	10	32.8±3.9	33.5±4.3	33.2±4.0
30.1-32	15	34.5±4.5	33.9±3.0	34.2±3.7
32.1-34	18	35.3±4.1	35.8±3.8	35.6±3.9
34.1-36	11	36.0±5.2	37.4±3.8	36.7±4.4
36.1-38	16	37.0±5.1	37.6±4.6	37.3±4.8
38.1-40	10	37.3±3.6	38.3±3.2	37.8±3.3

Table 1 shows the mean right and left kidney lengths at specific gestational ages, beginning from the 18th week of gestation.

There was a progressive increase in the kidney lengths in millimetres, with a progression of the gestation age and the mean kidney length increased

progressively from 15.2±2.4 mm at 18 weeks to 37.8±3.3 at 38 weeks of gestation (Fig. 2).

Fig. 2: Graphic representation of the foetal kidney length with gestational age

Table 2 describes the Pearson correlation coefficient for correlation between GA with routine foetal parameters like RKL, LKL, MKL, BPD, FL, HC and AC. Pearson's correlation coefficient (r) is a measure

of the strength of association between two variables. The correlation is significant at $p < 0.05$ level (2-tailed).

Table 2: Pearson correlation coefficients for relation between gestational age (GA) with foetal parameters among the study participants

Variables	GA	RKL	LKL	MKL	BPD	FL	HC	AC
GA	1	0.858*	0.885*	0.876*	0.952*	0.586*	0.904*	0.891*
RKL	0.858*	1	0.979*	0.995*	0.890*	0.569*	0.854*	0.788*
LKL	0.885*	0.979*	1	0.994*	0.910*	0.599*	0.866*	0.806*
MKL	0.876*	0.995*	0.994*	1	0.905*	0.587*	0.865*	0.801*
BPD	0.952*	0.890*	0.910*	0.905*	1	0.594*	0.939*	0.914*
FL	0.586*	0.569*	0.599*	0.587*	0.594*	1	0.589*	0.337*
HC	0.904*	0.854*	0.866*	0.865*	0.939*	0.589*	1	0.855*
AC	0.891*	0.788*	0.806*	0.801*	0.914*	0.337*	0.855*	1

Table 3 compares the regression model of change in GA, with respect to MKL.

Table 3: Regression model for mean kidney length (MKL) to predict gestational age ($R^2=0.768$)

Model 1	Unstandardized coefficients		Standardized coefficients	p-value	95% CI for B
	B	Std. Error	Beta		
(Constant)	6.624	1.107		0.000	4.434-8.814
MKL	7.389	0.352	0.876	0.000	6.692-8.086

An unstandardized coefficient represents the amount of change in a dependent variable (mean kidney length) due to a change of 1 unit of the independent variable (gestational age) in raw data. The standardized coefficient represents that for every 1 unit of change in gestational age, 0.876 unit changes occur in mean kidney length. This change is also

found to be statistically significant. The 95% Confidence Interval also indicates that if we repeat the same study in 100 different populations, 95% of times the values fall between these ranges. There was a strong positive correlation between GA and MKL as shown in Fig 3.

Fig. 3: Correlation between GA and MFL among the study participants. X- Mean kidney length in cm; Y- Gestational age in weeks, GA- Gestational age, MFL- Mean kidney length.

Table 4: Regression model for foetal parameters ($R^2=0.915$)

Model 2	Unstandardized coefficients		Standardized coefficients	p-value	95% CI for B
	B	Std. Error	Beta		
(Constant)	3.112	0.847	-	0.000	1.436-4.788
BPD	2.334	0.455	0.580	0.000	1.435-3.234
FL	0.285	0.103	0.113	0.007	0.080-0.489
HC	0.070	0.083	0.063	0.401	-0.094-0.233
AC	0.251	0.075	0.269	0.001	0.102-0.400

Table 4 compares the regression (change in GA with respect to change in other parameters like BPD/FL/HC/AC).

The standardized coefficient represents that 0.580, 0.113, 0.063- and 0.269-unit changes occur in BPD, FL, HC and AC, respectively. The significance in change with respect to GA was noted in BPD, FL and AC only, while the change in HC was not significant.

DISCUSSION

An accurate calculation of gestational age and the expected date of delivery (EDD) are imperative for an obstetrician for appropriate evaluation and follow-up of a pregnant woman (13). Many lab

investigations and screening tests for detection of congenital anomalies of the foetus are gestational age-specific (14, 15). Henceforth, an accurate gestational age calculation is important to monitor foetal growth and to determine the date and timing of delivery or induction of labour. It is of utmost necessity to know about the gestational age to plan deliveries in pregnancies with medical comorbidities like preeclampsia and for interventions like amniocentesis (16, 17).

Gestational age estimation by LMP has been the traditional method for many decades. In developing countries, where many pregnant mothers are illiterates, it becomes unreliable to assess the GA, based on the LMP that the pregnant mothers quote. In such a setting, it becomes important for the treating obstetrician to calculate the EDD from various other available sources.

Various biometric indices that were found useful in second-trimester continue to be used in the third trimester as well, despite substantial evidence indicating that the standard deviation for these measurements widens with advancing gestational age and therefore it is more important to assess the most accurate parameter and the method to assess it. As a result of it, various parameters like foetal foot length, foetal trans cerebellar diameter, amniotic fluid volume, placental thickness, placental grading, foetal kidney length, the transverse diameter of the colon and colonic echogenicity were studied. In this study, we evaluated the role of foetal mean kidney length measurements in the estimation of gestational age and compared its accuracy with other foetal biometric indices.

The mean BPD, FL, HC and AC measurements at various gestations observed in our study were similar to measurements obtained by previous authors (18, 19). 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 (20).

We found a very strong correlation between foetal mean kidney length and gestational age, similar to previous studies. The correlation coefficient ($r=0.768$) observed in our study was comparable with the studies done by Cohen et al ($r=0.82$) and Schlesinger et al ($r=0.859$) (21, 22). Correlation coefficients between gestational age and other biometric indices were also higher as compared to previous studies.

Also, studies conducted by Nahid *et al.*, Indu *et al.*, have found a very strong correlation between foetal kidney length and gestation age (23, 24). Verburg *et al.*, (25) found all foetal growth parameters were positively associated with the foetal kidney. There could be several numbers of reasons responsible for the difference occurring in between the studies.

These include the quality of the ultrasound machine, the expertise of the sonologist, high-risk pregnancies, etc.,

There has been tremendous progress in the quality of foetal monitoring in antenatal mothers in the last two decades. Despite all the progress made, as per the national population policy document, the first-trimester uptake and ultrasound uptake are only around 60%. This sub-optimal uptake explains why the perinatal problems are still high, despite 80% of deliveries happening at institutions (26). Sharma et al emphasize that the dating of pregnancy and gestational age estimation is an integral component of various risk models that predict the risk of pre-eclampsia in preterm births and foetal growth retardation (27). With further improvements in imaging techniques and with an increasing awareness of the indirect ways of gestational age assessment, peri-natal complications can largely be avoided.

CONCLUSION

Ultrasonographic measurement of the foetal mean kidney length is an easy way to assess the gestational age. It is one of the accurate parameters for estimating gestational age right from the second trimester till the end of pregnancy. This study proves that there is a good correlation between gestational age derived from foetal kidney length and that obtained from established biometric indices like biparietal diameter, abdominal circumference and femur length. The mean foetal kidney length collaborates nicely with gestational age in weeks. This parameter alone can predict the gestational age. Foetal kidney length can be combined with the other biometric indices to give a fair estimation of gestational age, which may be very useful in women with indeterminate LMP.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

REFERENCES

1. Wegienka, G., Baird, D. D. A comparison of recalled date of t menstrual period with prospectively recorded dates. J Womens Health (Larchmt) 2005; 14(3): 248-252.
2. Waller, D. K., Spears, W. D., Gu, Y., Cunningham, G. C. Assessing number specific error in the recall of onset of last menstrual period. PaediatrPerinatEpidemiol 2000; 14(3): 263-267.
3. Abonyi, E. O., Eze, C. U., Agwuna, K. K., Onwuzu, W. S. Sonographic estimation of gestational age from 20 to 40 weeks by foetal kidney lengths' measurements among pregnant women in Portharcourt, Nigeria. BMC Med Imaging. 2019; 19(1): 72.
4. Ugur, M. G., Mustafa, A., Ozcan, H. C., Tepe, N. B., Kurt, H., Alcil, E., *et al.*, Foetal kidney length as a useful adjunct parameter for better determination of gestational age. Saudi Med J. 2016; 37(5): 533-537.
5. Konje, J. C., Abrams, K. R., Bell, S. C., Taylor, D. J. Determination of gestational age after the 24th week of gestation from foetal kidney length measurements. Ultrasound Obstet Gynecol. 2002 Jun; 19(6): 592-597.

6. Hohler, C. W. Ultrasound estimation of gestational age. ClinObstet Gynecol. 1984 Jun; 27(2): 314-326.
7. Tse, C. H., Lee, K. W. A comparison of the foetal femur length and bi-parietal diameter in predicting gestational age in the third trimester. Aust N Z J Obstet Gynaecol. 1984 Aug; 24(3): 186-188.
8. Yeo, G. S., Chan, W. B., Lun, K. C., Lai, F. M. Racial differences in foetal morphometry in Singapore. Ann Acad Med Singapore 1994; 23: 371-376.
9. Jacquemyn, Y., Sys, S. U., Verdonk, P. Foetal biometry in different ethnic groups. Early Hum Dev 2000; 57: 1-13.
10. Yusuf, N., Moslem, F., Haque, J. A. Foetal kidney length: can be a new parameter for determination of gestational age in the 3rd trimester. TJA 2007; 20: 147-150.
11. Kumar, K., Lalwani, R., Babu, R., Malik, A. Ultrasonographic estimation of foetal gestational age by foetal kidney length. J Anat Soc India 2013; 62: 33-36.
12. Shivalinhaiah, N., Sowmya, K., Ananya, K., Kanmani, T. R., Marimuthu, P. Foetal kidney length as a parameter of determination of gestational age in pregnancy. Int J Reprod Contracep Obstet Gynecol 2014; 3: 424-427.
13. Committee on Obstetric Practice, The American Institute of Ultrasound in Medicine, and The Society for Maternal-Foetal Medicine. Committee Opinion No 700: Methods for estimating the due date. Obstet Gynecol 2017; 129: e150-154.
14. Petersson, K., Lindkvist, M., Persson, M., Conner, P., Ahman, A., Mogren, I. Prenatal diagnosis in Sweden 2011 to 2013 – A register- based study. BMC Pregnancy Childbirth 2016; 16: 365.
15. Loughna, P., Chitty, L., Evans, T., Chudleigh, T. Foetal size and dating: Charts recommended for clinical obstetric practice. Ultrasound 2009; 17: 161-167.
16. Panaitescu, A., Ciobanu, A., Syngelaki, A., Wright, A., Wright, D., Nicolaides, K.H. Screening for preeclampsia at 35-37 weeks' gestation. Ultrasound ObstetGynecol. 2018; 52: 501-506.
17. Figueras, F., Gratacós, E. Update on the diagnosis and classification of foetal growth restriction and proposal of a stage-based management protocol. Foetal Diagn Ther. 2014; 36: 86-98.
18. Peixoto, A. B., da Cunha Caldas, T.M.R., Dulgheroff, F. F., Martins, W. P., Araujo Júnior. E. Foetal biometric parameters: Reference charts for a non-selected risk population from Uberaba, Brazil. J Ultrason. 2017; 17(68): 23-29.
19. Hohler, C. W. Ultrasound estimation of gestational age. Clin Obstet Gynecol 1984; 27: 314-326.
20. O'Brien, G. D., Queenan, J. T. Growth of the ultrasound foetal femur length during normal pregnancy. AM J Obstet Gynecol. 1981; 141: 833.
21. Cohen, H. L., Cooper, J., Eisenberg, P., Mandel, F. S., Gross, B. R., Goldman, M. A., et al., Normal length of foetal kidneys: sonographic study in 397 obstetric patients. AJR Am J Roentgenol 1991; 157: 545-548.
22. Schlesinger, A., Hedlund, G., Pierson, W. P., Null, D. M. Normal Standards for Kidney Length in Premature Infants: Determination with US. Radiology 1987; 164: 127-129.
23. Nahid, Y., Moslem, F., Haque, J. A. Foetal Kidney Length: Can be a New Parameter for Determination of Gestational Age in 3rd Trimester. TAJ 2007; Vol 20, No 2:147-151.
24. Indu, K., Menia, V., Anand, A. K., Gupta, R. Role of Foetal Kidney Length in Estimation of Gestational Age. J K Science. 2012; 14(2): 65-69.
25. Verburg, B. O., Geelhoed, J.J.M., Steegers, E.A.P., Hofman, A., Moll, H. A., Witteman, J.C.M., Jaddoe, V.W.V. Foetal kidney volume and its association with growth and blood flow in foetal life: The Generation R Study. Kidney Int. 2007; 72(6): 754-761.
26. Lahariya, C. Cash incentives for institutional delivery: linking with antenatal and postnatal care may ensure 'continuum of care' in India. Indian J Community Med. 2009; 34(1): 15-18.
27. Sharma, L. K., Bindal, J., Shrivastava, V. A., Sharma, M., Choorakuttil, R. M., Nirmalan, P. K. Discordant dating of pregnancy by LMP and ultrasound and its implications in perinatal statistics. Indian J Radiol Imaging 2020; 30: 27-31.