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Estimation of Third-Trimester Gestational Age Using Ultrasonographic Fetal Renal Measurements: A Cross-Sectional Study

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ABSTRACT

Introduction: Accurate estimation of gestational age in the third trimester is challenging due to reduced reliability of conventional fetal biometric parameters such as biparietal diameter, head circumference, abdominal circumference, and femur length. Alternative sonographic markers may improve late gestational dating accuracy.

Methods: This cross-sectional observational study was conducted between December 2020 and November 2022 in the Armed Forces Medical College, Pune. The study included pregnant women with singleton pregnancies. All participants had uncomplicated pregnancies and were between 28 and 40 weeks of gestation at the time of enrolment. Ultrasonographic measurements of fetal kidney length and renal volume were obtained along with conventional fetal biometric parameters. Gestational age derived from a reliable last menstrual period was used as the reference standard. Pearson's correlation coefficient was used to assess the correlation between renal measurements and conventional biometric indices with gestational age.

Results: Ninety-six pregnant women were included in the study. The mean maternal age was 28.35 ± 5.05 years. Among 96 patients, the correlation of mean kidney length with last menstrual period -derived gestational age (GA) was strongest (r=0.875). Among the conventional biometric indices, GA from abdominal circumference showed a strong correlation (r=0.861), followed by femur length–based period of gestation (r=0.820), head circumference–based gestational age (r=0.804), and biparietal diameter-based gestational age (r=0.723).

Conclusions: Fetal kidney length can be a reliable and independent parameter for estimating gestational age in the third trimester and can be incorporated as a useful adjunct in routine obstetric ultrasonography.

Keywords: *Biometry; Femur; Gestational Age; Maternal Age*

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INTRODUCTION

Accurate assessment of gestational age is essential for optimal obstetric management and fetal growth monitoring. It is helpful for planning the appropriate time and mode of delivery and has a vital role in the management of high-risk pregnancies. Although first-trimester ultrasonography is considered the gold standard for pregnancy dating, many women present later with uncertain menstrual history, particularly in developing countries where routine access to health facilities is difficult.[1,2,3,4,5]

Conventional fetal biometric parameters such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) are widely used for gestational age estimation in the second and third trimesters. However, due to fetal head engagement, skull moulding, altered fetal lie, and individual growth variation, there is a progressive decrease in reliability in late gestation. At present, there is no single sonographic fetal dimension used for accurate estimation of gestational age in the third trimester.[2,4,6]

Fetal kidneys grow in a predictable and relatively linear manner throughout pregnancy and are less affected by the aforementioned factors. Several studies have demonstrated a strong correlation between fetal kidney length and gestational age, suggesting that renal measurements may serve as a reliable adjunct parameter for gestational age estimation in the third trimester. The present study aimed to evaluate the correlation between fetal renal measurements and gestational age and to compare their performance with conventional fetal biometric parameters.[2,4-13,15]

METHODS

This cross-sectional observational study was conducted in the Department of Radiodiagnosis and Imaging of a tertiary care teaching hospital over a period of two years, from December 2020 to November 2022. Ethical approval was obtained from the Institutional Review Committee of the hospital prior to commencement of the study (203/R/PG/2021). Participation was voluntary. Written informed consent was obtained from all participants in accordance with international ethical guidelines following tenets of the Declaration of Helsinki. The sample size for this study was calculated based on the method used for estimating a correlation coefficient. A confidence level of 95% ($1-\alpha = 0.95$) was considered, with an expected correlation coefficient (r) of 0.91. An allowable margin of error of 0.1 was assumed. Using these parameters, the minimum required sample size was 53. To improve the reliability of the results and account for possible measurement variability, a total of 96 participants meeting the inclusion criteria were ultimately included in the study.[2]

Only singleton pregnancies between 28 and 40 weeks' gestation with a reliable last menstrual period (LMP) and regular menstrual cycles without known complications were included in the study. Known complicated pregnancies, such as with growth restriction, congenital anomalies, oligohydramnios, polyhydramnios, multiple gestations, maternal systemic illnesses (such as diabetes mellitus or hypertension), or uncertain last menstrual period, were excluded from the study. Ninety-six women met the inclusion criteria and were included in the final analysis.

Ultrasound examinations were performed using a real-time GE Logiq P5 ultrasound machine equipped with a 3.5-MHz curvilinear transducer. Fetal kidneys were identified on grayscale ultrasonography and initially visualized in the transverse plane, followed by rotation of the transducer to obtain the true longitudinal plane.

Fetal kidney length was measured from the upper pole to the lower pole along the maximum longitudinal axis in the sagittal plane, ensuring exclusion of the adrenal gland and renal pelvis and avoiding oblique measurements. Renal breadth and anteroposterior diameters were measured in the transverse plane at the level of the renal hilum.[5,10,11,13] Renal volume was calculated using the ellipsoid formula:

Renal volume = length × breadth × anteroposterior diameter × 0.52.[8,16]

Figure 1: Ultrasound image showing measurement of fetal kidney length in the longitudinal plane. The kidney was visualized in the longest axis, and the distance between the upper and lower poles is measured, ensuring exclusion of the adrenal gland and renal pelvis

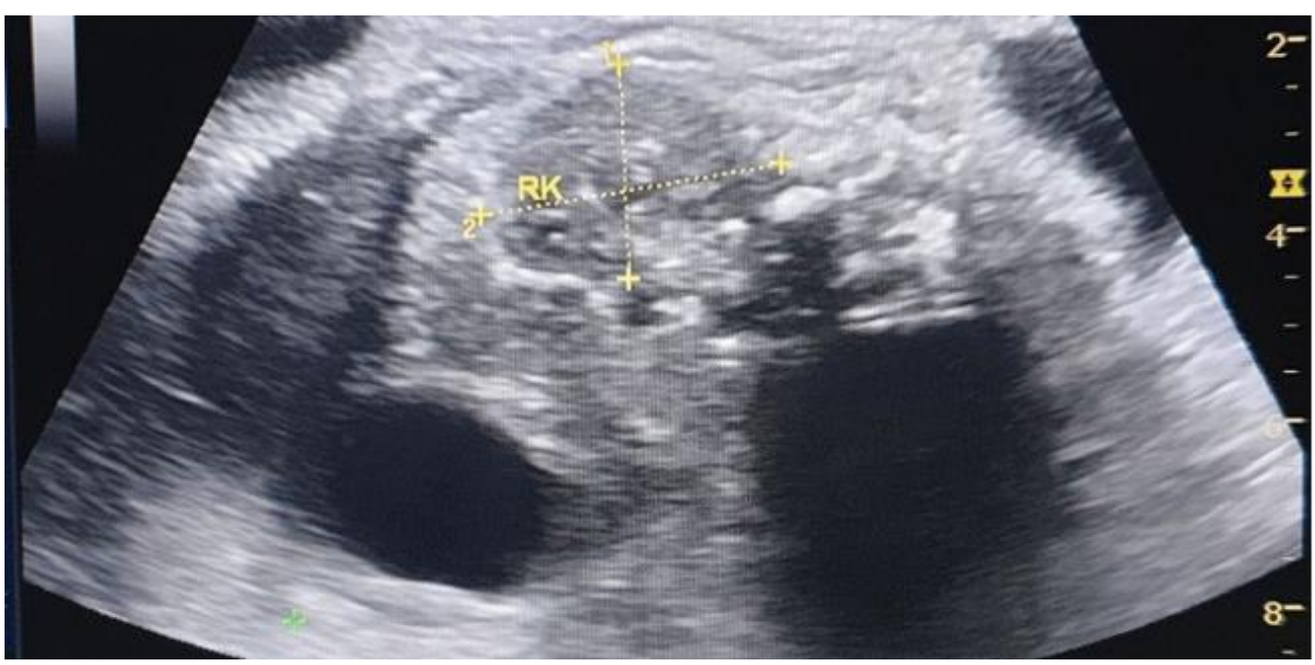


Figure 2: Ultrasound image dewwmonstrating fetal kidney breadth and anteroposterior diameter used for renal volume calculation

Conventional fetal biometric parameters, including BPD, HC, AC and FL, were measured according to standard obstetric ultrasound guidelines. Composite gestational age was calculated using them. Gestational age derived from reliable LMP was considered the reference standard.[1,3,17]

Statistical analysis was performed using IBM SPSS 26.0. Continuous variables were summarized as mean and standard deviation and Pearson's correlation coefficient was used to evaluate the relationship between fetal parameters and gestational age. A p-value < 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

The mean maternal age was 28.35 ± 5.05 years (range: 20-39 years).

Distribution According to the Period of Gestation

Based on LMP-derived gestational age, 28 (29.2%) participants were between 28-32 weeks, 50 (52.1%) between 33-36 weeks, and 18 (18.7%) between 37-40 weeks.

Gestational Age Estimation by Different Parameters

The mean gestational age based on reliable LMP was 34.30 ± 2.39 weeks. The mean gestational age estimated by BPD, HC, AC and FL was 33.53 ± 2.46 weeks, 33.82 ± 2.40 weeks, 33.35 ± 2.36 weeks, and 33.56 ± 2.52 weeks, respectively. The composite mean gestational age derived from HC, AC and FL was 33.26 ± 2.35 weeks. The mean fetal kidney length was 49.88 ± 2.65 mm, and the mean fetal kidney volume was 24.97 ± 3.33 cc.

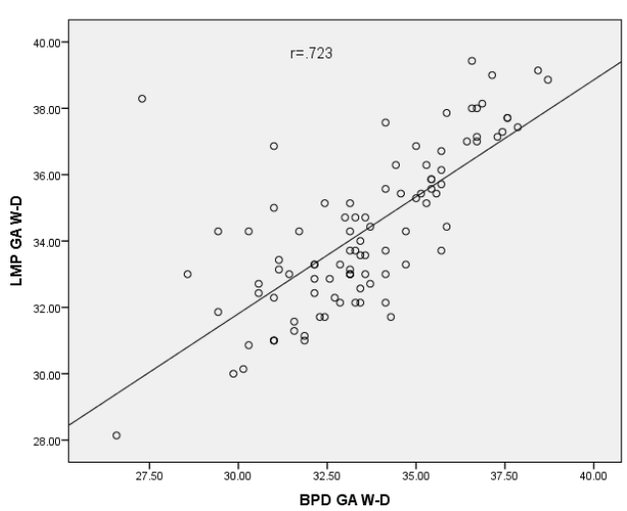
Table 1: Mean Gestational Age Estimated by Different Parameters and Renal Measurements (n = 96)

Parameter	Mean ± SD
Last menstrual period-based gestational age (weeks)	34.30 ± 2.39
Biparietal diameter -based gestational age (weeks)	33.53 ± 2.46
Head Circumference-based gestational age (weeks)	33.82 ± 2.40
Abdominal circumference-based gestational age (weeks)	33.35 ± 2.36
Femur length-based gestational age (weeks)	33.56 ± 2.52
Composite gestational age (weeks)	33.26 ± 2.35
Mean fetal kidney length (mm)	49.88 ± 2.65
Mean fetal kidney volume (cc)	24.97 ± 3.33

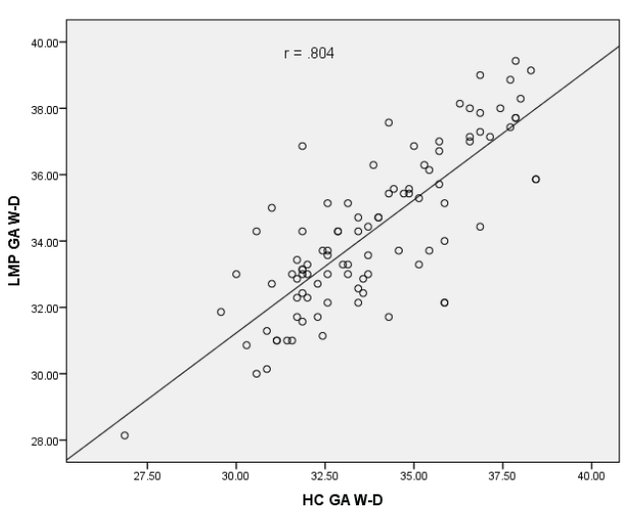
Correlation of Fetal Parameters with LMP-Derived Gestational Age

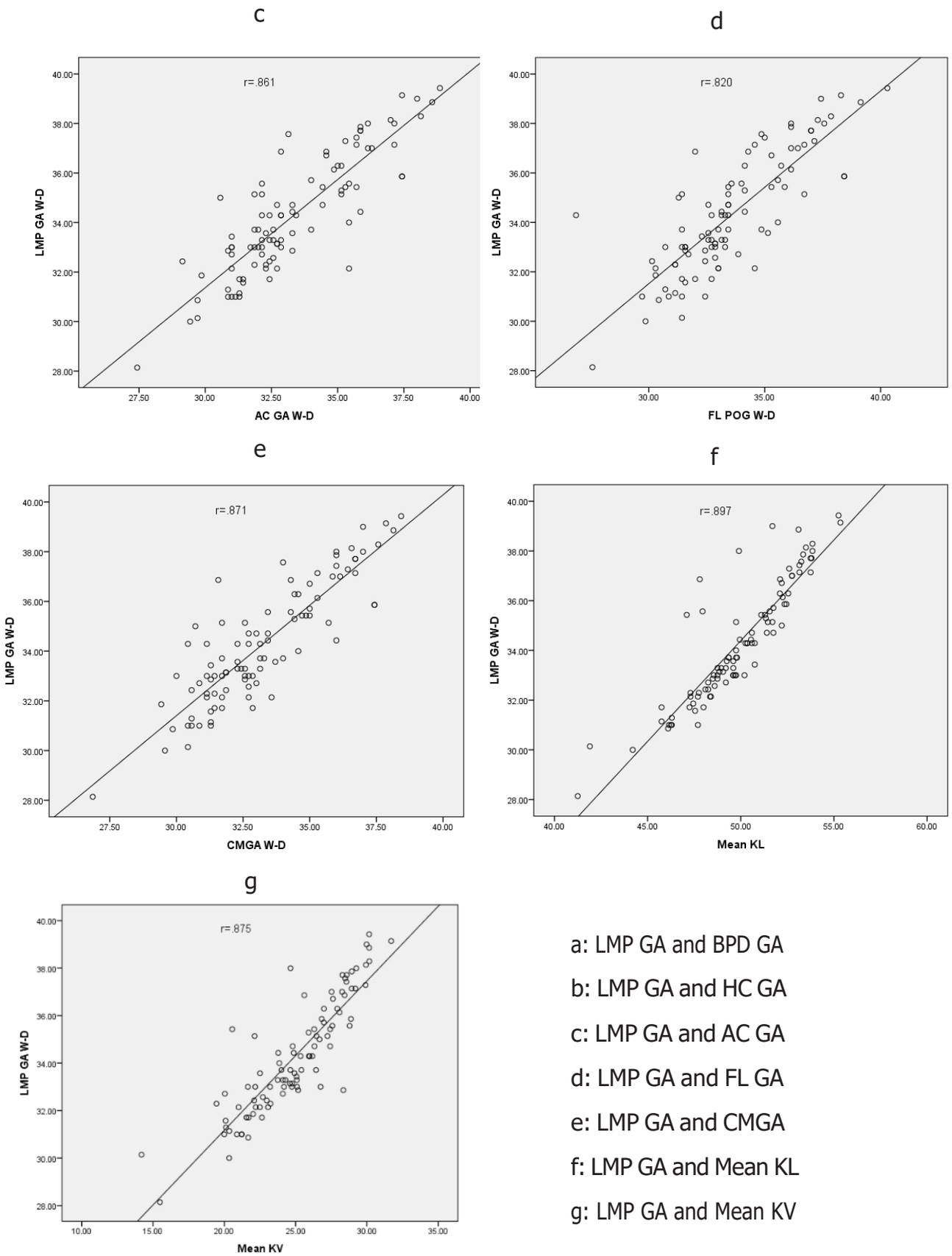
All parameters showed statistically significant correlation ($p<0.001$). The mean fetal kidney length showed the highest correlation with gestational age ($r=0.897$), followed by mean fetal kidney volume ($r=0.875$).

a



b





a: LMP GA and BPD GA

b: LMP GA and HC GA

c: LMP GA and AC GA

d: LMP GA and FL GA

e: LMP GA and CMGA

f: LMP GA and Mean KL

g: LMP GA and Mean KV

Figure 3: *Scatter plot showing correlation between LMP-derived gestational age and different parameters*

Subgroup Analysis Across Gestational Age Groups

Subgroup analysis demonstrated that fetal kidney length consistently showed strong correlation across all gestational age groups, particularly in the 28-32 week group.

Table 2: Subgroup Correlation Analysis of Fetal Parameters Across Gestational Age Groups

Parameter	28–32 weeks (r)	33–36 weeks (r)	37–40 weeks (r)
Biparietal diameter (mm)	0.706*	0.453*	0.006*
Head circumference (mm)	0.650*	0.526*	0.456*
Abdominal circumference (mm)	0.656*	0.615*	0.692*
Femur length (mm)	0.642*	0.481*	0.779*
Composite gestational age (weeks)	0.751*	0.571*	0.578*
Fetal kidney length (mm)	0.914*	0.559*	0.601*
Mean Fetal kidney volume (cc)	0.747*	0.602*	0.588*
*: p<0.001			

DISCUSSION

The present study demonstrates a strong and statistically significant correlation between fetal kidney length (FKL) and gestational age (GA) in the third trimester. Our study findings are consistent with findings from multiple previous studies conducted in various places in diverse population. In our cohort, FKL showed the highest correlation with the LMP derived gestational age as compared with conventional fetal biometric parameters. These results suggest potential superiority of FKL and FKV for estimation of gestational age in late pregnancy.[1,6,7,8,15,16]

The declining accuracy of traditional biometric indices such as BPD, HC, AC and FL in the late third trimester has been well documented. This might be due to influence of fetal head engagement, skull moulding, altered fetal lie, and individual variation in fetal growth. The reliability of available standard biometric formulas decreases with advancement of gestation and might worsen with conditions like growth retardation, fetal macrosomia etc. The fetal kidney has linear and steady growth pattern throughout gestation and are less affected by fetal position, growth disturbances, or head moulding making FKL and FKV more reliable. This relative biological stability likely explains the stronger correlation observed between FKL and gestational age in the present study.[4,6,11,13,14]

Several authors have reported that fetal kidney length increases at an approximately constant rate of about 1 mm per week after 24 weeks of gestation, making it a particularly attractive parameter for late gestational age assessment. Joshi BR et al. also found linear relationship during the late second (20 weeks to 28 weeks) and third (29 weeks to term) trimester between the fetal kidney growth measured in mm and the gestational age in weeks.[5,6,11,13,15]

The correlation decreased with increase in POG and FKV showed better correlation than FKL in the later stages. Our findings align closely with these observations and further reinforce the robustness of FKL as a gestational age predictor in the third trimester. Moreover, the strong agreement between FKL-derived gestational age and LMP-based dating observed in this study mirrors the narrow limits of agreement reported in recent literature, suggesting improved precision compared with conventional parameters.[16,18,19]

The findings ofthis study supporttheincorporation of fetal kidney length into routine obstetric ultrasound protocols, particularly in women presenting late in pregnancy with uncertain dates or unreliable menstrual history. In such clinical scenarios, reliance solely on conventional biometric indices may lead to inaccurate dating, potentially resulting in inappropriate obstetric decision-making. The addition of FKL as an

adjunct parameter may improve gestational age estimation, optimize timing of delivery, and reduce the risk of iatrogenic prematurity or post-term complications.[5,13,19]

The degree of correlation between gestational age and fetal kidney length was compared in various studies: the present study was in close agreement.

Table 3: Correlation coefficient of various studies

Study: FKL with gestational age	Pearson Correlation coefficient
Sanjib et al. (2018) in Odisha, India(2)	0.907
Gayam S. et al. (2018) in Hyderabad, India(11)	0.991
Mete G. Ugur et al. (2017) in Gaziantep University, Turkey(12)	0.947
Bardhan et al. (2016) in West Bengal, India (5)	0.99
Joshi BR et al. (2020) in Kathmandu, Nepal(15)	0.989
S Kathiresan et al. (2025) in India(9)	0.986
Our study	0.897
P value <0.001	

The correlation between fetal kidney length (FKL) and gestational age observed in the present study ($r=0.897$, $p<0.001$) is in close agreement with previously published literature across diverse populations. The previous studies have demonstrated strong positive correlations, with Pearson's correlation coefficients ranging from 0.907 to 0.991, all achieving statistical significance ($p<0.001$) as shown in the table above. Minor variations in correlation strength among studies may be attributed to various technical factors like differences in sample size, gestational age distribution, population-specific growth patterns and inter observer measurement techniques.

Bukhari et.al in Lahore in 2024 found, mean renal volumes for the right and left kidneys as 7.54 cm^3 (SD=2.14) and 7.55 cm^3 (SD=2.16), respectively. Gestational age (mean=33.58 weeks) and fetal weight (mean=2332.14 grams) exhibited strong correlations with renal volume ($r>0.94$, $p<0.001$) which is superior to our findings ($r>0.87$, $p<0.001$). Previously, in 2000, Chen-Hsiang Yu et al. found renal volumes are highly correlated with the fetal GA. Using gestational age as the independent variable and right renal volume (RRV) as the dependent variable, the best-fit regression equation was RRV (mL) = 0.74053 x GA (week) -13.318 ($r=0.89$, $p<0.001$). Similarly, the best-fit equation for the left renal volume (LRV) was LRV (mL) = 0.76093 x GA (week) - 13.421 ($r=0.86$, $p<0.001$). The study was conducted in 152 pregnant women using 3D USG in 2000 AD (Yu et al., 2000). Atsushi KUNO et al in Japan in 2005 found good linear correlation between left and right renal volumes ($r = 0.9614$, $P<0.0001$) by doing longitudinal study on 13 appropriate-for-gestational-age foetuses by measuring fetal renal volume every 2 to 3 weeks after 20 weeks gestational age until delivery. They found curvilinear relationships between gestational age and left and right renal volume (left: $R2 = 79.1\%$, $P<0.0001$; right: $R2 = 74.2\%$, $P<0.0001$). They generated normal ranges of left and right renal volume measurements for estimating the growth of the fetal kidney during normal pregnancy. E. K. Kiridi et al. found that the renal volume and dimensions were lowest in younger women and highest in older women. Also the renal volume increased as pregnancy advanced; and with increasing parity. The study was conducted in Nigerian population in 2021. Although researches are claiming that fetal kidney volume have good correlation with fetal gestational age, it is technically challenging and also not as easy as measuring the conventional parameters. With the emerging technology, if newer machines can calculate kidney volume automatically, practically correlation in every cases might be feasible.[19,20,21]

Despite its strengths, this study has certain limitations. Our study was cross-sectional observational study and they were not suitable for judging the appropriateness of the growth of kidneys across time. Gestational age was referenced to the last menstrual period rather than USG based GA by first-trimester crown–rump length measurement which is the gold standard for pregnancy dating. The single-center design and modest sample size, particularly in the 37-40 week gestational subgroup, may limit the generalizability of the findings and affect the stability of subgroup estimates.

Futureresearch should focus on large, multicenter prospective studies incorporating first-trimester dating as a reference standard. Studies can be done on same cohort to access growth of kidney volume over specific period of time. Prospective observation of the growth of the kidneys with subsequent increase in the gestational age can be studied in future. Development of population-specific nomograms and integration of fetal kidney length into multivariable gestational age prediction might be helpful in accurate estimation of GA, particularly in late gestation.

Although fetal kidney volume has also shown good correlation with gestational age, kidney length remains easier, practical and technically feasible parameter. Measurement of kidney length is technically simpler, less time-consuming, and more reproducible than volumetric assessment which require optimal image acquisition, longer operator time and also good expertise. From a routine obstetric ultrasound perspective, especially in resource-limited settings, FKL offers a favourable balance between accuracy and practicality.[4,5,6,10,11,12,13]

CONCLUSION

Fetal kidney length and also volume demonstrate strong linear association with third-trimester gestational age. Adding these parameters in routine obstetric ultrasonography may be helpful in appropriate estimation of fetal gestational age, particularly in those pregnancies which present late where conventional biometric indices show reduced precision. Further validation in larger and diverse populations is recommended before routine clinical adoption.

CONFLICT OF INTEREST

None

SOURCES OF FUNDING

None

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