



www.bioinformation.net
Volume 22(9)



Research Article

Received September 1, 2026; Revised September 30, 2026; Accepted September 30, 2026, Published September 30, 2026

DOI: 10.6026/973206300225674

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478

2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

Declaration on Publication Ethics:

The author's state that they adhere with COPE guidelines on publishing ethics as described elsewhere at <https://publicationethics.org/>. The authors also undertake that they are not associated with any other third party (governmental or non-governmental agencies) linking with any form of unethical issues connecting to this publication. The authors also declare that they are not withholding any information that is misleading to the publisher in regard to this article.

Declaration on official E-mail:

The corresponding author declares that lifetime official e-mail from their institution is not available for all authors

License statement:

This is an Open Access article which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly credited. This is distributed under the terms of the Creative Commons Attribution License

Comments from readers:

Articles published in BIOINFORMATION are open for relevant post publication comments and criticisms, which will be published immediately linking to the original article without open access charges. Comments should be concise, coherent and critical in less than 1000 words.

Disclaimer:

Bioinformation provides a platform for scholarly communication of data and information to create knowledge in the Biological/Biomedical domain after adequate peer/editorial reviews and editing entertaining revisions where required. The views and opinions expressed are those of the author(s) and do not reflect the views or opinions of Bioinformation and (or) its publisher Biomedical Informatics. Biomedical Informatics remains neutral and allows authors to specify their address and affiliation details including territory where required.

Edited by Ashwini Dhopte

E-mail: ashwinidhopte@gmail.com

Citation: Singh *et al.* Bioinformation 22(9): 5674-5678 (2026)

Fetal kidney length and volume for gestational-age estimation: A cross-sectional sonographic study, RIMS Ranchi

Sunila Kumari Singh*, Rajeev Kumar Ranjan, Suresh Kumar Toppo, Anima Ranjni Xalxo, Nisha Rai, Shailza raj jayaswal & Matsyangna Singh

Department of Radiodiagnosis, Rajendra Institute of Medical Sciences (RIMS) Bariatu, Ranchi, Jharkhand, India; *Corresponding author

Affiliation URL:

<https://rimsranchi.ac.in/>

Author contact:

Sunila Kumari Singh - E-mail: drsunila16@gmail.com
Rajeev Kumar Ranjan - E-mail: drrkranjanmd@gmail.com
Suresh Kumar Toppo - E-mail: rddrsuresh2205@gmail.com
Anima Ranjini Xalxo - E-mail: dr.animaxalxo@gmail.com
Nisha Rai - E-mail: nisha_zandels@yahoo.com
Shailza raj jayaswal - E-mail: drshailzaraj@gmail.com
Matsyangna Singh - E-mail: matsyangnasingh@gmail.com

Abstract:

Reliable gestational-age estimation becomes difficult when menstrual dating or early ultrasound is unavailable. Therefore, it is of interest to assess the fetal kidney length and volume as sonographic dating markers after 18 weeks in 240 singleton pregnancies. Bilateral renal measurements and routine fetal biometry were analyzed using correlation and regression methods. Gestational age correlated strongly with mean kidney length ($r = 0.9908$) and kidney volume ($r = 0.9656$; both $p < 0.001$). Thus, mean fetal kidney length showed the highest predictive accuracy and may complement routine biometry in late or uncertain dating.

Keywords: Fetal kidney length (FKL), fetal kidney volume, gestational age, ultrasonography, renal biometry, pregnancy dating

Background:

Accurate estimation of gestational age is central to antenatal care, interpretation of fetal growth, timing of investigations and decisions regarding obstetric intervention [1]. Early ultrasound dating remains the preferred approach, but many women present later with uncertain menstrual dates or without a reliable first-trimester scan [1, 2]. In the second and third trimesters, gestational age is usually estimated from biparietal diameter, head circumference, abdominal circumference and femur length, although prediction intervals widen as pregnancy advances. Late-pregnancy ultrasound dating is therefore less precise than early dating because biological variation in fetal size increases with gestation [1-3]. Fetal renal dimensions increase progressively during pregnancy and can be measured sonographically once the kidneys are clearly visualized in the second trimester [4, 5]. Recent studies have reported strong positive correlations between fetal kidney length and gestational age, supporting renal length as a useful adjunct when routine biometric dating is uncertain [4-6]. Renal size can be influenced by fetal growth restriction, which should be considered when interpreting renal measurements [7, 8]. Fetal kidney volume provides an additional three-dimensional estimate of renal growth, but it requires accurate measurement of multiple renal dimensions and may be more variable than simple length assessment [7, 8]. Recent evidence continues to evaluate fetal kidney length and volume as supplementary markers rather than replacements for established biometric parameters [4-8]. Local reference values may improve interpretation because renal dimensions can vary with population characteristics and measurement technique [4-6]. Recent studies from Nepal and India likewise reported strong gestational-age associations for fetal kidney length in mid-to-late pregnancy [5, 17]. Therefore, it is of interest to report the accuracy and reliability of fetal kidney length and kidney volume for gestational age estimation after 18 weeks of pregnancy in women undergoing antenatal ultrasonography at Rajendra Institute of Medical Sciences, Ranchi.

Materials and Methods:

The study was cross sectional observational study carried out in the Department of Radiodiagnosis, Rajendra Institute of Medical Sciences, and Ranchi, a tertiary care referral centre serving the urban and rural population of Jharkhand and adjoining areas. The total time of study was 18 months comprising of preparatory review, 12 months of data collection and analysis and final compilation of findings. The pregnant women were recruited consecutively from the antenatal ultrasound service until the required sample size was reached. The sample size was determined by the number of women eligible for detailed antenatal ultrasonography in the department and around 20 women were subjected to detailed antenatal ultrasonography monthly, so 240 women were included in the 12 months of enrolment. Women were eligible if they had a singleton pregnancy from 18 to 40 completed weeks of gestation, reliable last menstrual period, regular menstrual cycles, a first-trimester dating scan and a normal fetal anomaly scan at 20 to 24 weeks and normal amniotic fluid volume. Exclusion criteria were suspected intrauterine growth restriction, chromosomal abnormality, fetal structural anomaly, oligohydramnios or polyhydramnios, multiple pregnancies and any major maternal medical, surgical or obstetric condition that might interfere with fetal growth or interpretation of the images. All participants gave written informed consent for ultrasound examination. The Institutional Ethics Committee, RIMS, Ranchi, gave ethical clearance. The Philips Affiniti 70G ultrasound machine was used for ultrasound examinations, with a 2-5 MHz curvilinear transducer. The biparietal diameter, head circumference, abdominal circumference and femur length were first recorded as routine fetal biometry. To assess the kidneys, the fetal abdomen was scanned in the transverse plane, looking for the kidneys below the stomach and to the side of the spine. The transducer was then rotated to get the longitudinal axis of each kidney. The adrenal gland was excluded superiorly and adjacent bowel structures inferiorly. Measurements were made when the fetuses were not moving and repeated after 30-45 minutes when fetal position was suboptimal. The length of the right and left kidney was measured twice and the average length of the right and left kidney was obtained. Right and left kidney length was

averaged to determine mean kidney length. The renal width and anteroposterior diameter were also measured and kidney volume was calculated using the ellipsoid formula: volume = $\pi/6 \times \text{length} \times \text{width} \times \text{anteroposterior diameter}$. The bilateral renal measurements were used to estimate mean kidney volume. The data were entered in the Microsoft Excel and analyzed in SPSS version 26. The descriptive statistics were presented as mean $\pm$ SD, frequency and percentage. Paired t-test was used to compare the lengths of right and left kidneys. Independent t-test was used to compare second and third trimester values and one-way analysis of variance was used to compare the different gestational age groups. Pearson correlation was used to assess associations between gestational age and renal parameters. The linear regression equations for predicting gestational age were calculated for mean kidney length and mean kidney volume. A p-value of < 0.05 was regarded as statistically significant and p value of < 0.01 was regarded as strongly significant.

Results:

A total of 240 pregnant women with singleton pregnancies between 18 and 40 weeks were included. The mean maternal age was 26.3 ± 3.81 years. Most participants were in the 26-30-year age group (45.4%), followed by 21-25 years (35.0%). Multigravida women constituted 70.4% of the cohort, while primigravida women constituted 29.6%. Urban participants represented 53.8% and rural participants 46.3%. There were 104 women (43.3%) in the second trimester and 136 women (56.7%) in the third trimester (**Table 1**). The mean right kidney length was 29.24 ± 6.51 mm, while the mean left kidney length was 29.99 ± 6.48 mm. The overall mean kidney length was 29.61 ± 6.44 mm, with a range of 17.4-41.5 mm. The left kidney was slightly longer than the right kidney by a mean difference of 0.75 mm and this side difference was statistically significant on paired t-test ($t = -6.9769$, $p < 0.001$). The overall mean kidney volume was 3.50 ± 2.09 cm³, ranging from 0.57 to 8.48 cm³. Mean kidney length and kidney volume showed a steady rise across gestational age groups. Mean kidney length increased from 20.09 ± 1.62 mm at 18-22 weeks to 38.99 ± 1.19 mm at 38-40 weeks. Mean kidney volume increased from 0.99 ± 0.27 cm³ to 7.04 ± 0.67 cm³ across the same gestational intervals. One-way analysis of variance demonstrated a statistically significant difference

across gestational age groups ($p < 0.001$) (**Table 2**). When trimester-wise comparison was performed, mean kidney length was significantly higher in the third trimester than in the second trimester (34.42 ± 3.59 mm versus 23.32 ± 2.97 mm, $t = -26.17$, $p < 0.001$). Mean kidney volume was also significantly higher in the third trimester (4.99 ± 1.54 cm³ versus 1.57 ± 0.55 cm³, $p < 0.001$). Week-wise values showed a near-linear rise in mean kidney length from 18.44 ± 0.92 mm at 18 weeks to 40.25 ± 0.93 mm at 40 weeks, while volume increased from 0.71 ± 0.12 cm³ to 7.66 ± 0.61 cm³. Gestational age showed an excellent positive correlation with mean kidney length ($r = 0.9908$, $p < 0.001$) and a strong positive correlation with mean kidney volume ($r = 0.9656$, $p < 0.001$). The regression equation for gestational age prediction using mean kidney length was: GA (weeks) = $0.6089 + 0.9775 \times \text{MKL (mm)}$, with $R^2 = 0.9816$. For kidney volume, the equation was: GA (weeks) = $19.2537 + 2.9390 \times \text{volume (cm}^3\text{)}$, with $R^2 = 0.9323$ (**Table 3**). In comparative predictive ranking, mean kidney length showed the highest coefficient of determination, followed by head circumference, biparietal diameter, abdominal circumference, femur length and mean kidney volume. Maternal age did not correlate significantly with mean kidney length ($r = 0.0109$, $p = 0.8669$). Mean kidney length was similar between primigravida and multigravida participants (29.95 ± 6.61 mm versus 29.47 ± 6.38 mm, $p = 0.6053$). Urban participants showed a slightly higher mean kidney length than rural participants (30.39 ± 6.50 mm versus 28.71 ± 6.28 mm, $p = 0.0437$), although this difference requires cautious interpretation because gestational distribution and other potential confounders were not modelled separately.

Table 1: Baseline demographic and obstetric profile of study participants (n = 240)

Variable	Category	n	%
Maternal age	18-20 years	16	6.7
	21-25 years	84	35.0
	26-30 years	109	45.4
	31-35 years	30	12.5
	>35 years	1	0.4
Gravida status	Primigravida	71	29.6
	Multigravida	169	70.4
Residence	Urban	129	53.8
	Rural	111	46.3
Trimester	Second trimester (18-27 weeks)	104	43.3
	Third trimester (28-40 weeks)	136	56.7

Note: Mean maternal age was 26.3 ± 3.81 years.

Table 2: Fetal kidney length and volume according to gestational age groups (n = 240)

Gestational age group	n	Mean kidney length (mm), mean $\pm$ SD	Mean kidney volume (cm ³), mean $\pm$ SD
18-22 weeks	39	20.09 ± 1.62	0.99 ± 0.27
23-27 weeks	65	25.26 ± 1.58	1.91 ± 0.35
28-32 weeks	45	30.43 ± 1.54	3.36 ± 0.58
33-37 weeks	57	34.84 ± 1.66	5.05 ± 0.72
38-40 weeks	34	38.99 ± 1.19	7.04 ± 0.67

Note: One-way ANOVA showed significant increase across groups for renal parameters ($p < 0.001$).

Table 3: Correlation and regression analysis for gestational age estimation

Parameter	Correlation with GA (r)	Regression equation / predictive indicator	R ²	p-value
Mean kidney length	0.9908	GA = $0.6089 + 0.9775 \times \text{MKL}$	0.9816	<0.001
Mean kidney volume	0.9656	GA = $19.2537 + 2.9390 \times \text{volume}$	0.9323	<0.001
Head circumference	-	Comparative R ² for GA prediction	0.9739	<0.001
Biparietal diameter	-	Comparative R ² for GA prediction	0.9645	<0.001
Abdominal circumference	-	Comparative R ² for GA prediction	0.9593	<0.001
Femur length	-	Comparative R ² for GA prediction	0.9465	<0.001

Note: GA: gestational age; MKL: mean kidney length; R²: coefficient of determination

Discussion:

The present study shows that fetal renal measurements are very useful for gestational age estimation after 18 weeks. The mean kidney length in this group of 240 singleton pregnancies was found to increase gradually from the late second trimester to term and was nearly linearly related to gestational age. The correlation coefficient was 0.9908 and the regression R^2 was 0.9816, which suggest that the mean kidney length accounted for more than 98% of the variation in gestational age. These results validate the hypothesis that renal length is not just an anatomical measurement but a useful biometric parameter that can enhance the interpretation of routine antenatal ultrasound. This measurement has a clinical use because of the frequent issue of late presentation and ambiguous dating. While conventional biometry is still essential, the accuracy of BPD, HC, AC and FL decreases in the late second and third trimesters due to the fact that the growth patterns of fetuses become more individual. Among the parameters analyzed, mean kidney length was the most powerful predictor. This is not to say that renal biometry should be used in place of standard fetal biometry, but rather it should be used as an extra check when standard fetal biometry measurements are discordant or when the expected date of delivery is unclear. The mean kidney length of 29.61 ± 6.44 mm observed in 18-40 weeks is in keeping with the biological fact that renal length is closely related to gestational maturity during mid and late pregnancy. Previous cross-sectional studies also showed good correlation between renal length and gestational age, which makes it a reliable parameter when measured using a standard method [4-6, 9-12]. The present study builds on this evidence by adding length and calculated volume to a local tertiary-care population and by providing week-wise values over a wide gestational range. The left kidney was statistically longer than the right kidney by 0.75 mm. This side difference was statistically significant due to the sample size but the absolute difference is small and unlikely to impact clinical use if both kidneys are measured and averaged. This helps to avoid using one side of the kidney. The bilateral approach also minimizes the impact of fetal lie, acoustic shadowing and minor measurement differences. Later gestational age ranges have also been suggested for similar practical application of fetal kidney length as an adjunct parameter and good correlations have been reported between kidney length and other fetal dating parameters [6, 12-16]. The length of the kidney increases progressively from 18.44 mm at 18 weeks to 40.25 mm at 40 weeks, giving a clinically intuitive pattern. The parameter is easy to interpret at the scanning console because of the approximately 1 mm/week increase over most of the period studied. Simple renal length measurement may thus be a low-cost, reproducible supplement to the biometric set in settings where early dating scans are not available. Population-based studies based on fetal kidney length (20-40 weeks) have also highlighted the value of local reference values to enhance dating confidence in certain communities [4, 5 and 11-13]. Gestational age was also highly correlated with kidney volume, with the smallest group (18-22 weeks) having a volume of less than 1 cm³ and the largest group (30-34 weeks) having a volume of more than 7 cm³ near term. It

was highly correlated with gestational age but not as high as mean kidney length. This difference is clinically meaningful because volume is calculated from three measurements and a slight error in width or anteroposterior diameter may be compounded in the formula for the ellipsoid. Data from normal pregnancies confirms the positive relationship between renal length and gestational age and also highlights the importance of using a consistent measurement method to reduce the variability [4, 5 and 9-12]. The present volume findings are significant because renal volume might more accurately reflect three-dimensional organ growth and maturation of nephrons than a single linear dimension. But with regular use, there is the need for extra time and attention to acquire planes. Volume measurements of fetal kidneys, renal pelvis and adrenal gland have been published and have been found to be useful for establishing normative references, especially when ultrasound methodology is standardized [7, 8]. The relationship of fetal renal volume with gestational age has also been demonstrated by three-dimensional ultrasound, but the use of two-dimensional ultrasound routinely must be aware that volume estimation is more operator dependent than length measurement [7, 8]. The study also revealed that maternal age and gravida status were not significantly correlated with mean kidney length. This is clinically reassuring as it indicates that the length of the kidneys is mainly a reflection of fetal maturation in this selected low-risk group and not maternal chronological age or parity. The mean kidney length difference between urban and rural areas was statistically significant but should not be interpreted without taking into account the distribution of gestational weeks, nutrition, socioeconomic factors and referral pattern. In the general population of fetuses, the volume of the kidneys has been found to be associated with the patterns of fetal growth and blood flow; thus, additional research should include growth status and Doppler variables when examining demographic differences [7, 8]. One of the strengths of this study is the inclusion of 240 pregnancies over a continuous period from 18 to 40 weeks, which enabled the assessment of renal growth in the second and third trimesters. The standardized measurement protocol and calculation of mean bilateral renal length increases the practical applicability. The main drawbacks are its single-centre design, uneven week-wise distribution and the absence of formal interobserver and intraobserver reproducibility testing. The volume was measured by a two-dimensional ellipsoid method, rather than a true three-dimensional method, which may account for the slightly poorer predictive ability of volume compared to length. Local fetal biometric references are useful as growth patterns may differ in different populations and clinical situations and multicentre Indian data would enhance generalizability [4, 5]. In general, the results suggest that fetal kidney length is a very good secondary indicator of gestational age after 18 weeks. In this data set, mean kidney length was superior to renal volume and traditional parameters and renal volume was a helpful ancillary parameter. The addition of renal length to the standard obstetric ultrasound reporting may help to increase the accuracy of gestational dating, particularly in women who present late, women with

irregular periods and women where the other biometric parameters give inconsistent estimates. These findings agree with recent 2024 reports from Nepal and Ahmedabad showing that fetal kidney length tracks gestational age closely and can support dating in the later stages of pregnancy [5, 17].

Conclusion:

Fetal kidney length and volume increased predictably with gestational age after 18 weeks. Mean kidney length was the strongest renal predictor and outperformed the other evaluated biometric indicators in this dataset. Renal biometry may therefore provide a practical adjunct when standard late-pregnancy dating is uncertain.

References:

- [1] <https://pubmed.ncbi.nlm.nih.gov/32199122/>
- [2] Self A *et al.* BJOG. 2022 **129**:1447. [PMID: 35157348]
- [3] Smith GC & Nakimuli A. *Lancet Glob Health*. 2020 **8**:e462. [PMID: 32199109]
- [4] Kiridi EK *et al.* *Ethiop J Health Sci*. 2023 **33**:97. [PMID: 36890924]
- [5] Kandel D *et al.* *Post-Graduate Med J NAMS*. 2024 **24**:14. [DOI: 10.56974/pmjn.182]
- [6] Kumar V *et al.* *Cureus*. 2025 **17**:e77687. [PMID: 39974221]
- [7] Senra JC *et al.* *Prenat Diagn*. 2020 **40**:1408. [PMID: 32583885]
- [8] Adiyaman D *et al.* *Ginekolo Pol.* 2020 **91**:679. [PMID: 33301162]
- [9] Singh A *et al.* *J Ultrasound Obstet Gynecol*. 2021 **15**:4. [DOI: 10.5005/jp-journals-10009-1678]
- [10] Khalaf AS & Hassein MR. *J Pharm Negat Results*. 2022 **13**:S03. [DOI: 10.47750/pnr.2022.13.S03.151]
- [11] Shah J. *Natl J Med Res*. 2023 **13**:59. [DOI: 10.55489/njmr.13022023962]
- [12] Walad R *et al.* *Int J Reprod Contracept Obstet Gynecol*. 2023 **12**:2965. [DOI: 10.18203/2320-1770.ijrcog20232930]
- [13] Bob-Manuel IF *et al.* *Asian J Adv Res Rep*. 2023 **17**:24. [DOI: 10.9734/ajarr/2023/v17i6486]
- [14] Patel D *et al.* *J Clin Diagn Res*. 2023 **17**:QG01. [DOI: 10.7860/JCDR/2023/66393.18526]
- [15] Kathiresan S *et al.* *Cureus*. 2025 **17**:e77796. [PMID: 39981493]
- [16] Patel DJ. *Cureus*. 2026 **18**:e108887. [PMID: 42299211]
- [17] Jaradi J *et al.* *Glob J Res Anal*. 2024 **13**:2277. [DOI: 10.36106/gjra/3500798]

Caveat Emptor is applicable among the literate community where required and possible. The publisher, its journal, editors and the internal/external reviewers take adequate steps to check, evaluate, correct, edit, revise and improve content where possible and required.