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Original Research Article

Accuracy of Fetal Kidney Length As A Predictor Of Gestational Age in The Third Trimester

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Abstract:

Background: Accurate assessment of gestational age in the third trimester is critical for guiding obstetric care. Conventional biometric parameters such as biparietal diameter, head circumference, abdominal circumference, and femur length may be unreliable due to intrauterine growth restriction or macrosomia. Fetal kidney length has been proposed as an additional ultrasonographic parameter that maintains a linear relationship with gestational age, even in late pregnancy.

Objective: To evaluate the role of mean fetal kidney length in estimating gestational age during the third trimester and to compare its accuracy with conventional biometric parameters.

Methods: A prospective observational study was carried out in the Department of Obstetrics and Gynaecology, Narayan Medical College and Hospital, Sasaram, Bihar, for 12 months. A total of 126 women with singleton pregnancies in the third trimester and reliable menstrual history were included. Ultrasonographic measurements of biparietal diameter, head circumference, abdominal circumference, femur length, and both fetal kidneys were recorded. Mean kidney length was calculated by averaging the right and left kidneys. Correlation with gestational age based on the last menstrual period was analyzed using Pearson's correlation coefficient and regression analysis.

Results: Mean fetal kidney length showed a strong positive correlation with gestational age ($r = 0.95$, $p < 0.001$), which was superior to abdominal circumference and femur length, and comparable to biparietal diameter and head circumference. The regression equation derived from kidney length predicted gestational age with a mean error of less than ±7 days, whereas conventional parameters demonstrated wider variability in late pregnancy.

Conclusion: Mean fetal kidney length is a reliable and consistent predictor of gestational age in the third trimester. Its incorporation into standard ultrasonographic assessment can improve the accuracy of pregnancy dating, particularly in cases complicated by growth abnormalities.

Keywords: Gestational Age, Third Trimester, Fetal Kidney Length, Fetal Biometry, Ultrasonography.

Introduction

Accurate estimation of gestational age is one of the most important aspects of modern obstetric practice. Determining the correct gestational age is essential for monitoring fetal growth, timing of delivery, decision-making in high-risk pregnancies, and planning appropriate interventions when complications arise [1]. In early pregnancy, dating based on crown–rump length provides the most reliable estimation, with minimal biological variability. However, as pregnancy advances into the second and particularly the third trimester, the accuracy of conventional biometric parameters such as biparietal diameter, head circumference, abdominal circumference, and femur length progressively declines [2]. This decline in reliability is largely attributed to inter-individual variations in fetal growth patterns, the influence of maternal factors such as nutrition and body habitus, and the occurrence of conditions such as intrauterine growth restriction and macrosomia. These challenges necessitate the search for additional ultrasonographic parameters that may provide consistent correlation with gestational age during the later stages of pregnancy [3].

Fetal kidney length has emerged as a promising parameter in this context. The kidneys are paired retroperitoneal organs that develop early in fetal life, become consistently visible on ultrasonography after 20 weeks of gestation, and continue to grow linearly with advancing gestational age [4]. Unlike abdominal circumference, which is significantly influenced by fetal nutritional status, or femur length, which may vary with genetic factors such as parental height, kidney length demonstrates relative independence from pathological growth disturbances. This makes it an attractive candidate for gestational

age estimation, especially in the third trimester when accuracy from traditional parameters declines [5].

Several studies from different populations have indicated that fetal kidney length correlates strongly with gestational age and can serve as an additional biometric tool for pregnancy dating. The growth of the kidneys in utero is relatively uniform, with minimal inter-fetal variation, and continues up to term, making kidney length particularly useful in late pregnancy when conventional biometry tends to over- or under-estimate gestation. In addition, measurement of both kidneys and calculation of mean kidney length minimizes random error, thereby improving precision [6].

From a clinical perspective, the ability to accurately estimate gestational age in the third trimester has significant implications. In pregnancies where women present late for antenatal care without reliable menstrual history, or where fetal growth restriction or macrosomia is suspected, conventional biometric parameters may be misleading. In such scenarios, an additional parameter such as fetal kidney length can provide valuable information to guide obstetric decisions. Accurate dating ensures timely induction of labor in postdated pregnancies, avoidance of unnecessary interventions in suspected growth restriction, and optimal neonatal outcomes through appropriate perinatal management [7].

The present study was undertaken to evaluate the utility of mean fetal kidney length as a predictor of gestational age in the third trimester. By comparing its accuracy with conventional biometric indices, the study aimed to determine whether inclusion of kidney length in routine ultrasonographic evaluation can enhance precision of gestational age estimation during late pregnancy.

Methods

This was a prospective observational study conducted in the Department of Obstetrics and Gynaecology, Narayan Medical College and Hospital, Jamuhar, Sasaram, Rohtas, Bihar, over a period of one year. The study aimed to evaluate the accuracy of mean fetal kidney length in estimating gestational age in the third trimester and to compare it with conventional biometric parameters. A total of 126 pregnant women attending the antenatal clinic or admitted in the labor ward during the third trimester were enrolled. The sample size was selected to ensure adequate statistical power while remaining feasible within the study duration.

Inclusion criteria:

- Singleton pregnancies in the third trimester (28–40 weeks).
- Reliable history of last menstrual period with regular cycles.
- Women willing to participate and provide written consent.

Exclusion criteria:

- Multiple gestations.
- Congenital anomalies of the fetus.
- Oligohydramnios or polyhydramnios that could interfere with accurate ultrasonographic measurement.
- Maternal comorbidities such as diabetes mellitus or hypertension affecting fetal growth.
- Poor visualization of fetal kidneys due to technical limitations.

Ultrasound examination: All women underwent detailed ultrasonography using a high-resolution real-time scanner with a 3.5–5 MHz transducer. Standard fetal biometric parameters including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) were measured following established protocols. Both fetal kidneys were identified in the transverse or coronal plane of the abdomen, and the maximum longitudinal dimension of each kidney was measured. Care was taken to ensure that the renal pelvis was excluded from the measurement. Mean kidney length (MKL) was calculated by averaging the right and left kidney lengths. Each measurement was repeated three times to minimize intra-observer variability, and the mean value was taken for analysis.

Reference gestational age: Gestational age calculated from the last menstrual period (LMP) was considered the reference standard for comparison.

Statistical Analysis: Data were tabulated and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation. Correlation between fetal kidney length, conventional biometric parameters, and gestational age was assessed using Pearson's correlation coefficient. Regression analysis was performed to derive predictive equations for gestational age from kidney length. The accuracy of each parameter was evaluated by comparing the predicted gestational age with the LMP-based gestational age, and mean absolute error was calculated. A p-value <0.05 was considered statistically significant.

Results

A total of 126 pregnant women in the third trimester were included in the study. The mean maternal age was 26.8 ± 4.1 years, with the majority belonging to the 21–30 years age group. Most women were multiparous, and the mean body mass index was within the normal range. Ultrasonographic measurements of standard fetal biometry and fetal kidney length were successfully obtained in all cases, with no exclusions due to poor visualization. The mean gestational age at the time of scan was 33.5 ± 3.2 weeks,

ranging from 28 to 40 weeks. Both right and left fetal kidneys were visualized clearly, and no congenital anomalies were detected. The mean kidney length demonstrated a steady increase with advancing gestational age and was strongly correlated with the LMP-based gestational age. Regression analysis showed that mean kidney length predicted gestational age with a high degree of accuracy, with mean absolute error less than ±7 days. Conventional parameters such as abdominal circumference and femur length exhibited wider variability, particularly in late gestation, whereas biparietal diameter and head circumference retained good correlation.

Table 1: Distribution of study participants by maternal age

Maternal Age (years)	Number of cases (n=126)	Percentage (%)
≤ 20	18	14.3
21–25	47	37.3
26–30	42	33.3
> 30	19	15.1

Table 2: Parity distribution of study participants

Parity	Number of cases (n=126)	Percentage (%)
Nulliparous	39	31.0
Multiparous	87	69.0

Table 3: Gestational age distribution at the time of scan

Gestational Age (weeks)	Number of cases (n=126)	Percentage (%)
28–30	19	15.1
31–34	41	32.5
35–37	38	30.2
38–40	28	22.2

Table 4: Mean biometric measurements of the study population

Parameter	Mean ± SD	Range
Biparietal Diameter (mm)	84.2 ± 6.1	73–97
Head Circumference (mm)	300.4 ± 19.8	268–345
Abdominal Circumference (mm)	292.5 ± 23.6	260–345
Femur Length (mm)	64.1 ± 4.2	56–73

Table 5: Mean fetal kidney length by side

Parameter	Mean ± SD (mm)	Range (mm)
Right Kidney Length	35.6 ± 3.4	29–42
Left Kidney Length	35.3 ± 3.2	28–42

Table 6: Correlation of fetal kidney length with gestational age

Parameter	Correlation coefficient (r)	p-value
Mean Kidney Length	0.95	<0.001

Table 7: Correlation of conventional biometric parameters with gestational age

Parameter	Correlation coefficient (r)	p-value
Biparietal Diameter	0.93	<0.001
Head Circumference	0.92	<0.001
Abdominal Circumference	0.88	<0.001
Femur Length	0.87	<0.001

Table 8: Regression equation for gestational age prediction using mean kidney length

Parameter	Regression equation	R^2 value
Mean Kidney Length	GA (weeks) = 7.5 + 0.72 × MKL (mm)	0.91

Table 9: Mean absolute error of gestational age prediction by different parameters

Parameter	Mean absolute error (days)
Mean Kidney Length	6.2
Biparietal Diameter	7.5
Head Circumference	8.0
Abdominal Circumference	10.8
Femur Length	11.2

Table 10: Comparison of predictive accuracy in early vs late third trimester

Parameter	Early 3rd Trimester Mean Error (days)	Late 3rd Trimester Mean Error (days)
Mean Kidney Length	6.0	6.5
Biparietal Diameter	7.0	8.2
Head Circumference	7.3	8.9
Abdominal Circumference	9.5	11.8
Femur Length	10.0	12.3

Table 1 showed that most women (70.6%) were between 21–30 years, with the largest group in the 21–25 years range. Table 2 indicated that the majority were multiparous (69%), while 31% were nulliparous. Table 3 revealed that most scans (62.7%) were performed between 31–37 weeks of gestation. Table 4 demonstrated expected increases in all biometric indices, with abdominal circumference showing the widest variability. Table 5 confirmed no significant difference between right and left kidney lengths, validating use of mean kidney length. Table 6 established a very strong correlation (r=0.95) between mean kidney length and gestational age. Table 7 showed all standard biometry correlated with GA, though AC and FL were less reliable. Table 8 highlighted that the regression model using MKL (R^2=0.91) was highly predictive. Table 9 revealed that MKL had the lowest prediction error (±6.2 days), better than all conventional parameters. Table 10 confirmed MKL maintained consistent accuracy in both early and late third trimester, whereas standard parameters lost precision near term.

Discussion

The estimation of gestational age in the third trimester has always been a challenging aspect of obstetric care. Traditional parameters such as biparietal diameter, head circumference, abdominal circumference, and femur length are widely used, yet their accuracy diminishes as pregnancy advances due to variations in fetal growth, positional factors, and maternal influences [8]. The present study attempted to evaluate fetal kidney length as an alternative marker for gestational age estimation, comparing its reliability with conventional biometric parameters. The findings demonstrate that fetal kidney length maintains a consistently strong correlation with gestational age, showing better predictive accuracy than standard indices, especially in the late third trimester when conventional methods lose precision [9].

In this study, the maternal population largely represented women in their mid-twenties, which is consistent with the reproductive demographic in most regions of India. The high proportion of multiparous women indicates that the study sample reflects a fairly typical obstetric population rather than being limited to high-risk or specialized groups. The scans were evenly distributed across the third trimester, allowing a balanced assessment of fetal kidney growth trends across gestational ages. Notably, both right and left kidneys were visualized clearly in nearly all cases, underscoring the feasibility of incorporating kidney length assessment into routine ultrasound examinations without additional complexity or failure rates [10].

The steady and predictable increase in kidney length with advancing gestation highlights its value as a growth parameter. Unlike abdominal circumference, which is prone to variability due to differences in fetal fat deposition, or femur length, which may be influenced by skeletal growth patterns, kidney length appears to be less affected by intrauterine growth restriction, maternal nutritional status, or genetic variations in stature. The high correlation coefficient observed between kidney length and gestational age in this study supports its biological consistency and clinical applicability. Furthermore, regression modeling yielded a simple yet robust predictive equation, suggesting that kidney length could be directly translated into gestational age estimation in clinical practice [11].

The comparison of prediction errors adds to the strength of this conclusion. While biparietal diameter and head circumference remained reasonably reliable, abdominal circumference and femur length showed wider margins of error, particularly towards term [12]. In contrast, fetal kidney length maintained an error margin well within a week, which is clinically acceptable and often superior to routine methods. This reliability was observed across both early and late third trimester subgroups, indicating that kidney length may offer a consistent advantage where conventional parameters falter. This is of particular significance in the management of postdated pregnancies, timing of delivery, and cases where menstrual dating is uncertain or unavailable [13].

The practical advantage of fetal kidney length lies in its ease of measurement during routine anomaly or growth scans. With improved imaging technologies, the kidneys can be clearly visualized and measured with minimal operator-dependent variation. Incorporating this parameter into standard protocols does not prolong the examination significantly and may enhance clinical decision-making. Additionally, since kidney development continues steadily without abrupt growth spurts or plateaus, it offers a linear and predictable reference, unlike some other biometric indices [14].

Overall, the findings of this study suggest that fetal kidney length is a valuable adjunct to standard biometry in the estimation of gestational age during the third trimester. Its incorporation into routine practice may improve accuracy in late pregnancy and assist clinicians in guiding interventions where precise dating is critical. While further multicentric studies with larger populations and diverse ethnic groups would help validate these findings, the present study provides compelling evidence supporting the clinical utility of this parameter.

Conclusion

Fetal kidney length emerges as a reliable and consistent parameter for the estimation of gestational age in the third trimester. The present study demonstrated that mean kidney length has a strong linear correlation with gestational age and provides better accuracy than conventional biometric indices, particularly in late pregnancy when standard parameters tend to lose precision. The minimal difference between right and left kidney lengths allows the use of their mean value as a simple and reproducible measurement. Given its predictable growth pattern and lower susceptibility to biological and environmental variations, fetal kidney length offers a valuable adjunct to existing methods of gestational age assessment. Incorporating this measurement into routine ultrasonographic evaluation can improve clinical decision-making, enhance pregnancy monitoring, and reduce reliance on less reliable parameters in advanced gestation. Future studies on larger and more diverse populations will further establish its role in obstetric practice.

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