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Original Research Article

Pregnancy dating: Determining gestational age through fetal kidney length-what do we observe?

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ABSTRACT

Background: Accurate gestational age is crucial for obstetric care, pregnancy management, and preterm labor decisions. Ultrasound, based on fetal biometric parameters, is a reliable method for this purpose. This study aims to estimate gestational age in the third trimester using ultrasonographic methods, focusing on fetal kidney length. Gestational age is estimated in the third trimester by measuring fetal kidney length and comparing it with gestational age derived from other biometric parameters (bi-parietal diameter, head circumference, abdominal circumference, and femur length) and the last menstrual period (LMP).

Materials and Methods: A nine-month prospective study was conducted Kozhikode, Kerala, from September 2016 to May 2017. The study involved 200 women in their third trimester of pregnancy, utilizing third-trimester ultrasound to measure and document kidney length along with other biometric parameters (BPD, HC, AC, and FL). Subsequently, the collected data was reviewed and analyzed.

Results: The study revealed a strong positive correlation between fetal kidney lengths (FKL) measured in millimeters and gestational age in weeks during the third trimester. The correlation was significant, with a Pearson's correlation coefficient of 0.87 ($p < 0.001$). Additionally, FKL exhibited positive correlations with other variables, including abdominal circumference ($r = 0.832$), head circumference ($r = 0.845$), bi-parietal diameter ($r = 0.838$), and femur length ($r = 0.837$). These findings demonstrated a strong Pearson's correlation (r= 0.87-0.96, $P < 0.05$) for all the biometric parameters including FKL.

Conclusion: A linear relationship exists between fetal kidney length (FKL) and gestational age, allowing FKL to serve as an effective parameter for estimating gestational age during the third trimester. Given its positive correlation with other fetal biometric parameters such as bi-parietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL), incorporating FKL alongside these measurements enhances the accuracy of gestational dating in the third trimester. This combination of parameters improves the prediction of gestational age during this stage of pregnancy.

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1. Introduction

Accurate pregnancy dating plays a pivotal role in the management of expectant mothers, as numerous clinical decisions during pregnancy hinge on gestational age. In this context, obstetric ultrasonography has emerged as a crucial tool for precise gestational age estimation. Before the advent of sonography, gestational age was estimated using less reliable methods, such as the time elapsed since the first day of the last menstrual period (LMP) in a regular 28-day menstrual cycle, physical examination of uterine size, and maternal sensation of

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fetal movements ("quickening"). These approaches grow increasingly unreliable with advancing gestational age.[1,2]

Accurate knowledge of gestational age holds significant importance:

1. In the first trimester, it determines the timing of prenatal testing for fetal chromosomal abnormalities.
2. In the second trimester, it guides the optimal timing for anomaly scans.
3. It facilitates the assessment of fetal growth.
4. In the third trimester, it aids in the diagnosis and management of preterm labor, post-term pregnancies, and the determination of when medical intervention is necessary.
5. It allows for the anticipation of a normal delivery and the planning of cesarean sections within the appropriate time frame for term pregnancies.

The widespread acceptance of ultrasound in obstetric practice is due to its non-invasive, ionizing[3] safe,[4] cost-effective nature, high patient acceptance, and ability to provide comprehensive information. Recent advancements in ultrasound technology have improved the accuracy of gestational age assessment.[5] However, traditional methods like biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) are most accurate in the early second trimester and become less reliable as gestational age progresses.[6]

Fetal kidneys in the third trimester have a similar configuration to postnatal life, depending on gestational age.[7] Thus the main aim of this study was to evaluate the accuracy of gestational age estimation using fetal kidney length during the third trimester. Additionally, the study seeks to compare the gestational age estimated through mean fetal kidney length with that derived from traditional biometric parameters (BPD, HC, AC, and FL) as well as from the last menstrual period (LMP), thus determining the effectiveness of fetal kidney length as a reliable indicator for gestational dating in late pregnancy.

2. Materials and Methods

This prospective study involved 200 healthy women with uncomplicated pregnancies and accurate dates (in the first trimester), aged 28+0 to 38+6 weeks, for nine months. The study received approval from the Institutional Review Committee and written informed consent from all patients. Patients were excluded if there were fetal congenital anomalies, pregnancy complications, maternal disorders, or an unknown last menstrual period. Gestational age was determined based on a reliable last menstrual period, and a thorough clinical history was collected. Blood grouping and Rh typing were verified, and comprehensive hemogram, random blood sugar, and urine routine examinations were conducted.

Ultrasonography was performed during the third trimester using SIEMENS ACUSON X 300 and MINDRAY DP 50 ultrasound scanners. The third trimester ultrasound confirmed normal amniotic fluid index and ruled out fetal anomalies through an anatomical survey. Fetal kidney length measurements were obtained in the sagittal plane, and several parameters were collected during the ultrasound examination, including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), fetal kidney length (FKL), fetal heart rate, estimated fetal weight, and placental position done in the third trimester.

2.1. Statistical analysis

The study used SPSS 21.0 for data analysis, with graphs depicted using Microsoft Excel or SPSS itself. Continuous variables were summarized as mean ± standard deviation or median with inter quartile range, while categorical variables were summarized in terms of frequency with %. Continuous data was analyzed using independent sample t test or Mann Whitney U test and correlations between continuous variables were determined using Carl Pearson or Spearman correlation. Techniques of Linear regression models were used to predict Gestational age (GA) from Fetal kidney length (FKL), with a p value < 0.05 being considered statistically significant.

3. Results

A total of 200 women were examined during the nine month period. Table 1 provides the age demographic and indicates distribution was between the ages of 19 and 36 with mean age of 26.35

The mean LMP GA was found to be 32wks+6 days. The mean GA of the routine four parameters (BPD, HC, AC, and FL) were 32wk+3days. The mean GA of all the five parameters (BPD< HC, AC,FL, FK GA) were 32wk+3days.This showed that the mean GA of all the biometric parameter were comparable as illustrated by table 2

Pearson's correlation was calculated and a positive correlation between mean kidney length and gestational age as predicted by BPD, FL, AC and HC ($P< 0.001$)(Table 3) The correlation between gestational age and mean fetal kidney length was significant with Pearson's correlation coefficient value of 0.87 and significance being $P< 0.001$. Table 4 also illustrates a positive correlation with other variables as well like with AC ($r = 0.832$), HC ($r = 0.845$), BPD ($r = 0.838$) and FL ($r = 0.837$).

4. Discussion

Accurate gestational age determination is paramount in obstetric care, influencing various aspects such as interpreting antenatal tests, diagnosing fetal growth issues,

Table 1: Maternal age distribution

Age groups (in years)	Frequency	Percent	Median	Mean	SD	Range
< 20	6	3.0	26	26.35	3.86	19 - 36
20 – 24	62	31.0				
25 – 29	93	46.5				
30 – 34	34	17.0				
> 34	5	2.5				
Total	**200**	**100.0**				

Table 2: Mean, standard deviation, minimum, maximum obtained for gestational ages of various biometric parameters

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
LMPGA	200	32.63	3.152	.223	32.19	33.07	28	38
BPDGA	200	32.29	3.133	.222	31.85	32.73	27	39
HCGA	200	32.37	3.325	.235	31.90	32.83	26	39
FLGA	200	32.35	3.274	.232	31.89	32.81	26	39
ACGA	200	32.23	3.372	.238	31.75	32.70	26	39
FKGA	200	32.44	3.472	.246	31.96	32.92	26	40
Total	1200	32.38	3.286	.095	32.20	32.57	26	40

Table 3: Correlation of gestational age with other variables

Variable	Test statistic	BPD GA (in weeks)	HC GA (in weeks)	FL GA (in weeks)	AC GA (in weeks)	Fetal kidney length (in mm)
GA (in weeks)	Pearson Correlation	0.958**	0.960**	0.959**	0.956**	0.870**
	Sig. (2-tailed)	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001
	Number of subjects	200	200	200	200	200

and scheduling repeat cesarean sections. It also plays a pivotal role in assessing preterm labor or postdate pregnancies. Ultrasound, relying on precise fetal biometric parameters, offers a dependable method for determining gestational age and is recognized for its accuracy and reproducibility.

In this prospective study spanning nine months from September 2016 to May 2017, we collected data from 200 pregnant women. The participants had an age range of 19 to 36 years, with a mean age of 26.35. About 36.5% (n=73) were second gravida and 35.5% (n=71) were para-1.

Growth variation in the fetus affects all organs including the kidney but only in the Antero posterior and transverse diameter not the length.[8,9] Initial work showed fetal kidney is easy to identify, but, a study conducted by Duval et al.[10] encountered difficulty in imaging kidney in breech presentation and in vertex presentation with back facing laterally or posteriorly. There was no problem in identifying, measuring and reproducing the same measurement of kidney length in the present study. Due to minimal differences between left and right kidney measurements, we opted to measure a single proximal kidney, regardless of fetal sex, as gender did not influence fetal kidney measurements.[11]

Our study reveals a robust correlation between fetal kidney length (FKL) and gestational age during the third trimester, demonstrating a linear relationship between FKL (in millimeters) and gestational age (in weeks). This correlation is statistically significant, with a correlation coefficient of 0.87 ($p < 0.05$), aligning with prior studies such as Cohen et al. (1991) and Konje et al. (2002), which also concluded that FKL can accurately date pregnancies. This underscores the utility of FKL, particularly in situations where measuring other biometric parameters, such as biparietal diameter (BPD) or head circumference (HC) due to an engaged head, or abdominal circumference (AC) in cases of intrauterine growth restriction (IUGR), may prove challenging. In such scenarios, FKL can be employed independently to accurately estimate gestational age.

Furthermore, our findings indicate a positive correlation between FKL and other biometric parameters, including abdominal circumference (AC), head circumference (HC), biparietal diameter (BPD), and femur length (FL). Notably, the fetal kidney length values in our study exceeded those reported by Cohen et al.[12] and Jeanty et al.[13] This variation may be attributed to differences in study design (cross-sectional vs. longitudinal), methods of gestational age estimation (rounded vs. exact), ultrasound machine quality

Table 4: Correlation between measured gestational age (GA) of various biometric parameters (LMP, BPD, HC, FC, AC and FKL)

		LMP GA (in weeks)	BPD GA (in weeks)	HC GA (in weeks)	FL GA (in weeks)	AC GA (in weeks)	Fetal kidney length (in mm)
LMP GA (in weeks)	**Pearson Correlation**	1	.958**	.960**	.959**	.956**	.870**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	200	200	200	200	200	200
BPD GA (in weeks)	Pearson Correlation	.958**	1	.929**	.915**	.919**	.838**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	200	200	200	200	200	200
HC GA (in weeks)	Pearson Correlation	.960**	.929**	1	.916**	.923**	.845**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	200	200	200	200	200	200
FL GA (in weeks)	Pearson Correlation	.959**	.915**	.916**	1	.915**	.837**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	200	200	200	200	200	200
AC GA (in weeks)	Pearson Correlation	.956**	.919**	.923**	.915**	1	.832**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	200	200	200	200	200	200
FETAL KIDNEY LENGTH (in mm)	Pearson Correlation	.870**	.838**	.845**	.837**	.832**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	200	200	200	200	200	200

**. Correlation is significant at the 0.01 level (2-tailed).

(older vs. newer), the number of operators involved, and potential racial disparities.

The regression equation, Fetal kidney gestation age = 1.35 + (0.9 x Fetal kidney length), demonstrates a strong correlation (r = 0.9) and high explanatory power (R^2) between FKL and gestational age. The charts of fetal kidney length generated from cross-sectional data are suitable for comparing renal size at a known gestational age with reference data; however, they are not designed for assessing kidney growth over time.

Comparing mean gestational ages, we observed that FKL and the routine four parameters (BPD, HC, AC, and FL) yielded comparable estimates. Combining various parameters in predictive models produced results similar to individual parameters, consistent with the findings of Hadlock et al.[14] The most effective predictive model in our study encompassed all five parameters (KL, FL, BPD, HC, and AC), suggesting the potential for further enhancements in accurate gestational dating by incorporating multiple fetal biometric parameters. However, determining the optimal combination of these measurements warrants further investigation.

5. Limitations

The study has limitations, including a small population size, inability to compare pre and post pregnancy renal lengths, and only taking measurements of the proximal kidney, which would have been appropriate for both kidneys. A larger study would provide improved accuracy.

6. Conclusion

The study demonstrates two significant findings. Firstly, a linear relationship exists between fetal kidney length (FKL) and gestational age, supporting the utility of FKL as an independent parameter for estimating gestational age, particularly in the third trimester when traditional biometric indices may be less reliable. Secondly, FKL exhibits positive correlations with other fetal biometric parameters such as BPD, HC, AC, and FL. This suggests that incorporating FKL into gestational age predictions can enhance accuracy, particularly in cases of uncertain dates and late presentation for ultrasound biometry dating. As technology in obstetric ultrasound continues to advance, including the transition from 2D to 3D and 4D imaging, we are presented with new parameters like FKL, trans-cerebellar diameter, and bipolar diameter of the kidney, which contribute to more precise gestational age estimation alongside conventional parameters like BPD, HC, AC, and FL.

7. Author Contribution

Dr Fathimathul Jusna prepared the protocol, collected data, assessed eligibility and methodological quality of studies and wrote the review. Dr Tajunnisa and Dr Ramakrishnan conceived the idea, conducted searches, assessed eligibility and quality of studies. Dr Saikrishna N and, Dr Ambika Premarajan provided comments on the manuscript. Dr Lakshmi Nair performed the statistical analysis and Dr Heera Shenoy T provided comments on the manuscript and supervised the review.

8. Source of Funding

None.

9. Conflict of Interest

None declared.

10. Ethical Consideration

The ethical approval for the research was provided by the following institutions, IMCH , Kozhikode according to the principles of Helsinki Declaration.

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