Evaluation of the Normal Fetal Kidney Length and Its Correlation with Gestational Age

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Abstract- A true estimation of gestational age (GA) plays an important role in quality maternity care and scheduling the labor date. This study aimed to evaluate the normal fetal kidney length (KL) and its correlation with GA. A cross-sectional study on 92 pregnant women between 8th and 10th week of gestation with normal singleton pregnancy underwent standard ultrasound fetal biometry and kidney length measurement. univariate and multivariate linear regression analysis was used to create a predictive equation to estimate GA on the KL and fetobiometry parameters. A significant correlation was found between GA and KL (r=0.83, *P*<0.002). The best GA predictor was obtained by combining head circumference, fetal biparietal diameter, femur length and KL with a standard error (SE) about 14.2 days. Our findings showed that KL measurements combination with other fetal biometric parameters could predict age of pregnancy with a better precision.
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Keywords: Anthropometry; Fetal Ultrasonography; Gestational Age; Kidney

Introduction

A true estimation of gestational age (GA) plays an important role in quality maternity care such as assessment of fetal growth and to schedule the labor date. Any inaccurate estimation may lead to perinatal morbidity and mortality due to iatrogenic pre- or post-maturity. The first day of the last menstrual period (LMP) is used for pregnancy dating in a regular 28-day menstrual cycle. However, there is some evidence that about 30% of women forget their accurate LMP or misunderstand early pregnancy bleeding as normal menses (1,2). Also, inaccuracy of estimation in pregnancy dating may be as a result of delay ovulation due to hormone therapy or oligo-ovulation. The development of diagnostic ultrasound has opened new possibilities for more confident assessment of dating. GA can be estimated in the first trimester by ultrasonic measurement of diameter and volume of gestational sac as well as crown–rump length (CRL) (3-5). Also, other biometric indices such as fetal biparietal diameter (BPD), femur length (FL) transcerebellar diameter (TCD), clavicle length (CL), foot length, and head circumference (HC) are used for GA estimation during different pregnancy trimesters (5).

Although fetal biometry measurements indicated accurate indices for GA estimation in the early second trimester, the biological diversity of size lead to change in accuracy of these parameters as the age of fetus advanced and a true dating in late second or third trimester is difficult. So, some studies focused on the association of kidney size in a normal fetus with gestational age (6-8). The aim of this study was to evaluate the normal fetal kidney length (KL) and its correlation with gestational age.

Materials and Methods

This cross-sectional study was performed between February 2006 and September 2008 on pregnant women referred to Quaem Hospital in Mashhad, Iran. The study protocol was approved by research ethic committee of the Mashhad University of Medical Sciences. All participants signed an informed consent before entering into the study. Participants who met the inclusion criteria were women with singleton pregnancies, having a certain LMP, an ultrasound test performed between 8th and 10th week of pregnancy, a previous ultrasound measurement of CRL, and less than 5 days difference between LMP and ultrasound calculated GA.

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Ultrasonographic fetal KL measurements were performed using an ATL HDI 3000 ultrasound machine (Advanced Technology Laboratories Philips, Bothell, WA, USA) equipped with a 4.2 MHz curvilinear transducer, based on a previously published technique described by Bertagnoli *et al.* (9). Identification of the adrenal gland and its exclusion from the measurements should be achieved for each test. Pregnancies with oligohydramnios (amniotic fluid index, AFI less than 5 cm) or polyhydramnios (AFI of more than 25 cm), chromosomal or other structural abnormalities, dilated renal pelvis (more than 5 mm), and diabetic mothers were excluded. All measurements were performed by two skilled operators.

Information was obtained about maternal height and weight before pregnancy. GAs were determined by using Hadlock's chart of predicted fetal measurements at specifics menstrual weeks for BPD and FL and his GA/abdominal circumference chart for abdominal circumference (AC). All measurements were made during fetal apnea. When the kidneys were visualized just below the stomach in a transverse plane scanning of the fetus, the kidneys length were measured and then with a 90° rotation of the probe the longitudinal axis of the kidneys were measured. All ultrasound measurements were repeated twice by each operator and the mean values were calculated to reduce experimental variation.

An analysis of variance was used to compare mean renal length for each week of gestational age. Pearson product moment correlation coefficients were used to measure the degree of relationship among the various biometric gestational age measurements.

All statistical analyses were done using SPSS, version 16 (SPSS, Chicago, Illinois). Pearson correlation was used to determine the association between continuous quantitative variables. Univariate and multivariate linear regression analysis was used to create a predictive equation to estimate GA on the KL and fetobiometry parameters. For each model, the standard error of the prediction in days was calculated for subjects with mean values of the anthropometric measurements included. All hypotheses tests were 2-tailed with $P<0.05$ considered significant. Data are presented as mean ± standard deviation (SD) for quantitative variables and frequency and percent for qualitative variables.

Results

Out of 92 eligible women, 89 completed the study. The mean age of them was 28.4±5.3 (range 18 to 40) years. Thirty-six of the neonates (40.4%) were males and 28 were females (missing= 25 cases). There were no sex differences in the renal and fetal biometric indices ($P>0.05$).

The mean KL, FL, AC and HC had a linear and strong correlation with LMP derived dates. The best correlation coefficient was observed between LMP and FL (Table 1). There was no statistically significant difference between the measurements of the left and right kidneys ($P>0.05$). Also, no statistically correlation coefficient was observed between KL and maternal height ($P>0.05$). A significant correlation was found between GA (days) and KL (mm) (r=0.83, $P<0.002$).

Table 2 shows the equations derived from linear regression analysis when the individual variables were considered separately. The most accurate was the AC with a standard error (SE) of 0.06 day, after that HC (SE=0.10 day) and BPD (SE=0.55 day). While the most inaccurate was the FL with a SE of 0.63 days.

Table 3 shows derived models of GA prediction by the combination of various biometric indices. These models indicate that the best GA predictor can be obtained by combining HC, BPD, FL and KL with a SE about 14.2 days.

Table 1. Pearson correlation coefficient for relation between gestational age (LMP) with biometric indices and kidney length.

	LMP	BPD	HC	AC	FL	RKL
BPD	0.928**					
HC	0.876**	0.918**				
AC	0.813**	0.873**	0.849**			
FL	0.932**	0.964**	0.931**	0.892**		
R KL	0.825**	0.834**	0.837**	0.779**	0.862**	
L KL	0.836**	0.853**	0.852**	0.785**	0.878**	0.963**

AC: abdominal circumference; BPD: biparietal diameter; FL: femur length; HC: head circumference; KL: kidney length; LMP: last menstrual period.
** *P* value<0.001

Table 2. Linear regression analysis of fetal biometric parameters.

	Unstandardized Coefficients		Standardized Coefficients	*P* value
	B	SE	Beta	
(Constant)	18.532	12.640		0.147
FL	1.984	0.632	0.603	0.002
BPD	1.101	0.558	0.378	0.052
HC	0.046	0.104	0.052	0.662
AC	-0.071	0.065	-0.107	0.275

Dependent Variable: LMP

AC: abdominal circumference; BPD: biparietal diameter; FL: femur length; HC: head circumference; LMP: last menstrual period.

Table 3. The models derived from the various biometric indices summery combination.

Model	R	R^2	Adjusted R^2	SE of the Estimate	Change Statistics				
					R^2 Change	F Change	df1	df2	Sig. F Change
1	0.918(a)	0.842	0.840	15.44	0.842	420.434	1	79	0.000
2	0.919(b)	0.844	0.840	15.44	0.002	0.957	1	78	0.331
3	0.927(c)	0.860	0.854	14.72	0.016	8.863	1	77	0.004
4	0.928(d)	0.860	0.853	14.29	0.001	0.273	1	76	0.603

a Predictors: (Constant), BPD

b Predictors: (Constant), BPD, HC

c Predictors: (Constant), BPD, HC, FL

d Predictors: (Constant), BPD, HC, FL, KL (mean)

e Dependent Variable: LMP

BPD: biparietal diameter; FL: femur length; HC: head circumference; KL: kidney length; LMP: last menstrual period.

Discussion

Age of pregnancy can be accurately estimated by diameter and volume of gestational sac and measurement the length of fetal crown-rump throughout the early pregnancy. Also, fetal biparietal diameter and length of the femur can be used during the later gestational stages. The accuracy of ultrasonic biometry has been calculated and it has been showed that these parameters predicted the age of pregnancy within 4.7 and 6-10 days respectively during the first 10 weeks and up to 24th week of gestation. This method has led to a significant decrease in the number of labor induction for suspected prolonged pregnancy (8). Although these biometric indices are inaccurate in late stages of pregnancy, they are continued to be used among women with uncertain LMP in late stages. So, several studies were performed to determine an accurate estimation of GA by ultrasonic investigation during the late second and third trimesters. Ozat *et al.*, carried out a study on 2,184 pregnant women and established a nomogram of fetal sacral length in different fatal ages for assessment of GA (10). They found sacral length as an easily acquired and valuable index with a direct and strong correlation with GA as well as other fetal biometry parameters. Sherer et al in a study on 602 pregnancies and used fetal hard palate width, length and area as indicators of GA with relative ease between 15 and 41 weeks' gestation and showed that hard palate parameters were well correlated with GA, BPD, AC, FL and ultrasonic estimated fetal weight (11). Several other studies have been made on this issue, but nevertheless none of their methods are practically used for gestational dating, because the ultrasound dating method should be simple, easy to define and reproducible. Similar to our study, an investigation by Konje *et al.*, was performed on 85 pregnant women and used the length of fetal kidney for prediction the age of pregnancy (8). They indicated that KL between 24 and 38 weeks of pregnancy was a more accurate technique for determining GA than other feta-biometry parameters such as BPD, HC, FL, and AC. Another study in India by Kansaria *et al.*, demonstrated that by measuring KL, pregnancies could be dated within 9.17 days (12).

Studies indicated that only the anterior–posterior and transverse diameters of the fetal kidney are changed in

different growth conditions and KL is unchanged in small-for-gestational age fetuses (8). Hence, some attempts stated that the anterior-posterior diameter of the kidney can be used to identify fetal growth problems (13,14).

In our study the kidneys were easily identify in the third trimester and both kidneys in all cases were measurable. However, when only one kidney can be measured in difficult cases, the insignificant differences between the left and right KL does not affect the GA estimation (8).

Our findings showed that KL measurements combination with other fetal biometric parameters could predict age of pregnancy within ± 14.29 days. A better precision for prediction of GA than other model such as using AC and FL was observed by application of KL measurement. The benefit of this method is more significant in the absence of BPD and/or HC measurements due to unfeasibility of ultrasonic evaluation in the correct plane or when the fetal head is too low. In this situation, only KL can be used to estimate the age of pregnancy.

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