Journal of Medicine in Scientific Research

Volume 2 | Issue 2 Article 10

Subject Area:

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Recommended Citation

Shalaby, Ibrahim Elmorsy and Abdelrazek Abo-Donia, Mahmoud Elsayed (2019) "Determination of gestational age by ultrasonographic measurement of fetal kidney length during third trimester of pregnancy," *Journal of Medicine in Scientific Research*: Vol. 2: Iss. 2, Article 10.
DOI: https://doi.org/10.4103/JMISR.JMISR_91_18

Original Article

Determination of gestational age by ultrasonographic measurement of fetal kidney length during third trimester of pregnancy

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Abstract

Objective

The aim of accurate estimation of gestational age is reduction of fetal and maternal morbidity and mortality as much as possible. The routine fetal biometry ultrasound (US) measurement at third trimester is not adequate all times; for this purpose, new parameters must be developed. Average fetal kidney length (FKL) is one of them and may add value as a single parameter.

Design

A prospective study to assess the gestational age at the third trimester using FKL US measurement was done.

Patients and methods

Seventy-five noncomplicated pregnant women at third trimester (25 as a training sample and 50 as a validating sample) were included in the study. All of them had accurate date of last menstrual period and had regular follow-up at the Department of Obstetrics and Gynecology. Routine US biometry and FKL were done. The training sample was used to calculate a regression equation of gestational age by FKL, and then the validation of the regression equation was done on the validating sample.

Main outcome measures

To compare the results of gestational age by FKL measurement derived from the regression equation to gestational age by sure last menstrual period date to calculate accuracy and standard error of the estimate.

Results

There is a strong correlation between gestational age by date and estimated average kidney length in the third trimester, using linear regression analysis (Pearson's $r = 0.871$; $P > 0.001$). The derived regression equation [gestational age using FKL (days)=51.1165 + 5.02 × average kidney length (mm)] could estimate the actual gestational age with an accuracy of ±6.4 days (SE of the estimate).

Conclusion

Average FKL can be used as a new single parameter with some degree of confidence for determination of gestational age at the third trimester.

Keywords: Fetal kidney length, gestational age, ultrasound

Introduction

Accurate determination of gestational age plays a significant role of reduction of postdate labors, which improves both fetal and maternal care and reduces postnatal complication. It is the only way to know the adequate timing of mandatory interventions and the avoidance of early or late interventions [1].

The use of ultrasound (US) biometric routine parameters, including biparietal diameter (BPD), head circumference (HC),

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Access this article online

Quick Response Code:

Website: www.jmsr.eg.net

DOI: 10.4103/JMISR.JMISR_91_18

How to cite this article: Abo-Donia ME, Shalaby IE. Determination of gestational age by ultrasonographic measurement of fetal kidney length during third trimester of pregnancy. J Med Sci Res 2019;2:148-51.

abdominal circumference, femoral length (FL), and fetal weight, is mandatory at all pregnancies starting from 20 weeks [2]; however, late at pregnancy, all these parameters are not very accurate owing to either difficult technical issues, intrauterine growth retardation, or complicated pregnancy. These measurements showed significant discrepancy, which was observed with daily practice especially late at third trimester [3].

Many studies have been performed in the past two decades concerning the sonographic assessment of fetal kidney length (FKL). At early research phases, many studies were done for diagnosis of fetal renal malformation and later on, they were done to assess the correlation between FKL and gestational age [4]. Many authors confirmed that FKL is not affected by the discrepancy of late trimester or by intrauterine fetal growth retardation [5]. FKL has a steady growth of 1.7 fortnightly through pregnancy [3].

Patients and Methods

A prospective study was carried out at the Department of Obstetrics and Gynecology, Shebeen ElKom Teaching Hospital, during the period October 2016 to October 2017 after obtaining clearance by the hospital ethical committee (Shebeen Elkom Teaching Hospital Medical Research Committee), with date of approval 2–6–2016, and number of approval 637. In our opinion, FKL US assessment is a part of routine examination with no exposure of hazards to any patients. A total of 75 pregnant women consented to participate in this study.

Study participant groups

(1) Training sample:
A total of 25 pregnant women had previous excellent regular follow-up at our department outpatient clinic from the first trimester, and analysis of this group was used to derive an equation for gestational age from FKL.
(2) Validation sample:
A total of 50 pregnant women were used as the validation sample, and this group was used to validate the derived equation.

Inclusion criteria

The following were the inclusion criteria:
(1) Normal, uncomplicated pregnancy at third trimester.
(2) Single fetus.
(3) Both kidneys (fetal) clearly visualized with no abnormal morphology.
(4) Regular cycles and excellent dated determined by three factors.
   (a) Sure of their date.
   (b) Reliable: regular last three cycles before pregnancy without the use of hormonal contraception.
   (c) Confirmed by first trimester US.

Exclusion criteria

The following were the exclusion criteria:
(1) Complicated pregnancy conditions (diabetes mellitus, hypertension, or intrauterine growth retardation).
(2) Polyhydramnios or oligohydramnios.
(3) Abnormal fetal renal morphology.
(4) If the adrenal or renal border is not well defined.
(5) For all participants, careful history was taken, sure last menstrual period date was estimated, and expected date of delivery was calculated according to Naegle's formula Last menstrual Period (EDD = LMP + 7 days–3 months + 1 year).

Ultrasound examination

(1) Fetal biometry estimated the date of delivery with standard fetometry (BPD, HC, FL, and abdominal circumference) as well as estimated fetal weight.
(2) Measurement of both right and left FKL was done by a single expert radiologist. The US machine used is GE Logic S6 (General Electric, NY, USA). The fetal body was scanned in the transverse plane until the kidney is visualized just below the level of the stomach. The probe is rotated through 90° to outline the longitudinal axis of the kidney during the appearance and confirm the kidney completely separable from the suprarenal gland; each maximum kidney length was recorded, and then the average was taken.

Statistical analysis

Data were analyzed using MedCalc 8, version 14C (MedCalc software, bvba, Ostend, Belgium). Mean and SD were calculated for kidney length. In a training sample, simple linear regression modeling was used to assess the relationship between estimated by FKL and gestational age using maternal parameters (LMP), and the regression equation for Gestational Age (GA) using FKL was calculated. The accuracy of the equation was validated on validation sample by calculation of the SE (est) and gestational age using FKL (days) = 51.1165+(5.02 × average kidney length, mm).

Results

Mean gestational age by date for training sample was 180 ± 3 days and for validation sample was 179 + 13 days. Mean average kidney length for training sample was 25.7 + 2.1 mm, and for validation, the sample was 25.3 + 19 mm.

At training sample

A simple linear regression model analysis for relation between the gestational age by date and average FKL assessed by the ultrsound, the regression equation derived from this regression analysis is shown at Table 1. Then diagnostics of regression model using analysis of variance showed statically significant difference between the explanatory variable (average kidney length) and the outcome (GA by date) (F ratio, 44.932; df, 1; P value, <0.001). The average kidney length could explain as much as 66.1% variation in the gestational age (coefficient of determination, R^2, 0.661) (Table 2).

At the validation sample

(1) Pearson's correlation coefficients between GA by date and average FKL are presented in Table 3, with positive correlation between the FKL and gestational age as estimated by date (Pearson's r, 0.831; $P < 0.0001$).
(2) Pearson's correlation coefficients between GA by date

Table 1: Simple linear regression analysis for the relation between the gestational age by date and the mean kidney length

Parameters	Regression coefficient	SE	95% CI	*t*	*P*
Intercept	51.1165	19.333	11.123-91.110	2.644	0.015
Slope	5.02	0.749	3.4707-6.569	6.703	<0.0001

CI, confidence interval; *t*, *t* statistic.Regression equation=gestational sac of the average kidney size as gestational age by date (days)= 51.1165+ (5.02×average kidney length for both side in mm)

Table 2: Diagnostic of regression model by using analysis of variance

Sources	df	Sum of squares	Mean square	*F* ratio	*P*
Regression	1	2765.444	2765.444	44.932	<0.0001
Regression	23	61.548	61.548	44.932	<0.0001

R^2=0.661.df, the degree of freedom; R^2, the coefficient of determination.

Table 3: Linear regression analysis testing: correlation analysis between the mean kidney length and gestational age by date

Metrics	Value
Sample size	50
Correlation coefficient (Pearson's *r*)	0.813
95% CI for *r*	0.616-0.915
P value	<0.0001

CI, confidence interval.

Table 4: Validation of regression equation: correlation analysis for the relation between the fitted gestational age and gestational age by date

Metrics	Value
Sample size	50
Correlation coefficient	0.871
95% CI for *r*	0.782-0.925
P value	<0.0001

CI, confidence interval.

and GA by FKL are presented at Table 4, with very strong positive correlation between the fitted (predicted) and actual gestational age as estimated by date (Pearson's *r*, 0.871, $P < 0.0001$). The assessment of overall accuracy of the average FKL was done for estimation of the gestational age. The derived regression equation could estimate the actual gestational age with an accuracy of ±6.4 days [SE (est), ±6.4 days], which could be regarded as an accepted margin of accuracy from a clinical perspective.

Discussion

Basic fetal biometry assessment that depends on usual biometric parameters (FL, HC, AC, and BPD) fails owing to inaccurate estimation of fetal age in the third trimester, despite high resolution of new US machines, especially with no available accurate menstrual history [4], so there is a need for newly developed parameters that are characterized by easy, accurate, and very reproducible is an obligatory. Newly developed US machines have very higher resolutions to image fetal organs and estimate their size. Many authors recommended using a FKL as a new parameter because it is not affected by the discrepancy of late trimester or by fetal growth retardation [5].

FKL measurement is more accurate at late pregnancy because of a technical issue. At early pregnancy, the kidneys and suprarenal glands have the similar appearance of echogenicity and maybe inspirable, but at the third trimester, the perinephric fat becomes more apparent, which makes the outline of the kidneys easily separable from adjacent structures especially the suprarenal gland [6]. In our study, one of the exclusion criteria is the ill-defined adrenal or renal borders.

In our study, there is a strong significant correlation between the average kidney length and gestational age by date (correlation coefficient $r = 0.83$; $P < 0.05$), which is the approximate result of Peter *et al*. [6] who estimate FKL as a parameter from 20th weeks to term with *r* 0.974 and *P* value less than 0.001, as well as previously reported results from Cohen *et al*. [7] ($r = 0.82$), Konje *et al*.[8] ($r = 0.91$), Toosi and Delu [9] ($r = 0.825$), and Shivalinhaiah *et al*. [3] ($r = 0.85$). All these studies with narrow zone of variation confirm the best correlation of FKL and gestational age and make the idea of usage of FKL as a single parameter more near to be used.

Another strong significant correlation was found between estimated age by average kidney length and gestational age by date ($r = 0.87$, $P < 0.05$). This matched with the results of various studies, such as Peter *et al*. [6], with correlation coefficient *r* of 0.896, and as well as previously reported results from Uger *et al*. [10] ($r = 0.947$), and was higher compared with Gupta *et al*. [2] ($r = 0.615$). Despite all studies confirming the functional relation between gestational age by date and gestational age by FKL and high possibility of use of kidney length as a new parameter (either solo or part of other parameters), there is some variation of correlation coefficient. Moreover, this could be explained by the variable generation of US machine used (new or old), degree of experience of the US operator, single or multiple US operators included in same study, as well as the design of the study (restrict studies of noncomplicated pregnancies vs. studies with complicated pregnancies).

The present study derived an equation for estimation of the gestational age from the FKL with SE ±6.4 days. The equation was obtained from the results based on using two distinct samples, a 'training sample' (25 cases) that was used to derive the equation, and a 'validation sample' (50 cases) that was used to validate the derived equation. The validation results of regression equation have been compared with study done with Konje *et al*. [8] with SE 10.29 days; Kansaria and Paruleker [11], with SE 9.17 days; Peter *et al*. [7] with SE

9.04 days; and Kaul *et al*. [12] with SE 8.56 days. From our study, the gestational age using FKL as single measurement with SE of 6.4 days may introduce a new helpful method for determination of gestational age in women with forgotten or inaccurate LMP.

The limitation of the study is the small samples size, which needs more studies at different centers to validate our regression equation calculated for gestational age from average FKL.

Conclusion

The third trimester-estimated gestational age using average FKL calculated from our study regression equation may add a great value in the estimation of actual gestational age and can be used in the future as a single parameter; however, this validation equation needs multicentric studies and a large number of sample to validate or even modify its constant factor.

Acknowledgements

no anything to discloseMahmoud Elsayed Abdelrazek Abo-Donia checked the clinical history of all cases, designed the study, and wrote the manuscript and Ibrahim Elmorsy Shalaby did US examination on a specific protocol for all cases and also did the statistical analysis.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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