Original Article

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Ultrasonography of Normal Fetal Kidney Width Measurement for Estimation of Gestational Age in Sudanese Pregnant Women

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ABSTRACT

Background: A precise estimate of gestational age (GA) is essential for providing optimal maternity care and determining the labor date. **Aim:** This study aimedto determine gestational age between the 14th and 40th weeks for Sudanese pregnant women by measuring the normal fetal kidney width using ultrasound. **Methods**: The study was designed as a descriptive cross-sectional study in Khartoum and Gezira states, Sudan, from June 2016 to May 2017. Three hundred ninety healthy pregnant women aged between 15 and 45 years were assessed by ultrasound, with overall normal well-being fetuses. Linear regression models for estimating gestational age were developed based on biometric markers and kidney width. Stepwise regression models were created to determine the most effective model for measuring gestational age that occur between 14 and 40 weeks. Comparisons were subsequently made between the models' effectiveness in identifying gestational age. **Results**: The most accurate variable parameter assessed in this study was kidney width, with a standard error (SE) of 0.02 days, followed by kidney length (SE = 0.04 days), biparietal diameter (BPD) (SE = 0.10 days), and femur length (FL) (SE = 0.13 days). The abdominal circumference was the least accurate, with an SE of 1.35 days. There was a strong association between GA and kidney width ($R = 0.72$, $P < 0.002$). **Conclusions**: The kidney width (KW) is easy to identify and measure. It is the most accurate parameter for estimating GA compared to other biometric indices in the late second and third trimesters and could be easily incorporated into models for estimating GA.

Keywords: Age estimation, kidney length, ultrasound, radiograph.

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INTRODUCTION

Accurate GA estimation is essential for obstetricians to diagnose growth disorders, assess incorrect or forgotten dates, and timing decision of delivery either by induction or cesarean section.[1] Fetal growth assessment, either clinically or through ultrasound evaluation, also relies on accurate GA assessment. Proper decisions regarding presumed preterm labor or post-date pregnancies are only possible when GA is accurately estimated. Likewise, the timing of repeat cesarean sections requires accurate date assessment.[2]

Ultrasound is a reliable method for establishing the length of pregnancy and can improve obstetric care. Sonographically measured fetal renal length is an accurate and useful tool for assessing fetal renal growth and well-being.[3] Ultrasonography of fetal measurements is highly reliable in the first and second trimesters of pregnancy; however, the reliability of any ultrasound method diminishes as gestation advances. In the third trimester, the reliability of any single ultrasound parameter is poor.[4] Ultrasound assessment for GA is becoming increasingly important, with many parameters being used to establish GA, such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). Recently, the evaluation of the posterior fossa of the fetal cranium has been accepted as part of routine obstetrical estimations.[5,6] While BPD was the first fetal parameter clinically utilized to determine GA in the second trimester, more recent studies have evaluated the use of several other biometric parameters, including HC, AC, FL, foot length, ear size, orbital diameters, cerebellum diameter, and others.[7,8] However, as GA progresses, these parameters become increasingly unreliable due to biological variability in size in relation to age.[9] Accurate dating of pregnancies in the late second trimester or third trimester remains a challenging problem, especially for women who seek maternity care late and are uncertain of their last menstrual period (LMP) date. The fetal kidney grows progressively with GA; therefore, ultrasonographic examination can predict GA at any trimester. Parameters such as BPD and others are thought to compute GA more accurately when performed at earlier gestations.[10] The fetal kidney is easy to identify and measure.[11,12] but has not been extensively studied as a biometric index for GA estimation, although ultrasound textbooks often include tables of different dimensions. In this prospective study, we evaluated the accuracy and reproducibility of kidney width measurements in predicting GA in the second half of pregnancy. Additionally, we compared the accuracy of this method with that of BPD, HC and FL.

MATERIALS AND METHODS

This study was designed as a prospective cross-sectional study in Khartoum and Gezira states, Sudan. The fetal kidneys of 390 pregnant women were assessed at different phases of pregnancy at the Department of Radiology in Al Saudi Maternity Teaching and Wadmedani Military Hospitals during the years 2016-2017. The study group involved 390 pregnant Sudanese women referred to an obstetric clinic with gestational ages ranging from 14 and 40 weeks. Aged between 15 and 45 years, all women who fulfilled the inclusion criteria were included in the study population. The study population, representing various Sudanese ethnicities, was limited to Khartoum and Gezira states. All investigations and ultrasonographic measures were taken in hospitals utilizing standardized transabdominal procedures. However, kidneys with unclear outlines were excluded from the study due to unclear adrenal or renal boundaries, aberrant renal morphology, renal pelvic dilatation of more than 4 mm in anteroposterior diameter, pregnancy-associated hypertension, diabetes mellitus, cardiac diseases, thyroid disease, repeated cesarean sections, or intrauterine fetal death. We selected these criteria despite the fact that dilatations of up to 1 cm may be seen in fetuses without clinical signs of renal obstruction or vesicoureteral reflux at birth, in order to avoid any implication of falsely lengthy kidney measurements caused by dilatation. The BPD is measured in the transverse axial plane. BPD diagnosis involves identifying intracranial landmarks such as the falx cerebri in the back, the cavum septi pellucid in the front, and the paired midline region thalami and Sylvian fissure on the side. The FL is measured with the bone crossing the beam axis. The substantial acoustic shadow behind the femoral shaft, as well as the visualization of both cartilaginous ends, suggested that the image plane was on the longest axis. These kidney widths were evaluated in relation to GA determined by BPD, FL, and AC, as well as the average of those three GAs in weeks, which we referred to as average weeks. These measurements were compared to gestational ages obtained by LMP and, in a few cases, CRL and HC. The longest renal widths were also investigated in relation to maternal height, weight, BMI, and age. The data (mean ± standard deviation) were analyzed using the SPSS Statistical Package for Social Sciences (version 16; SPSS Inc, Chicago, IL, USA). A p-value of less than 0.05 was considered statistically significant. The research and ethical committee of the Faculty of Medicine, National Ribat University, Sudan, approved the study, and verbal consent for study conduction was obtained from the patients and hospital directors.

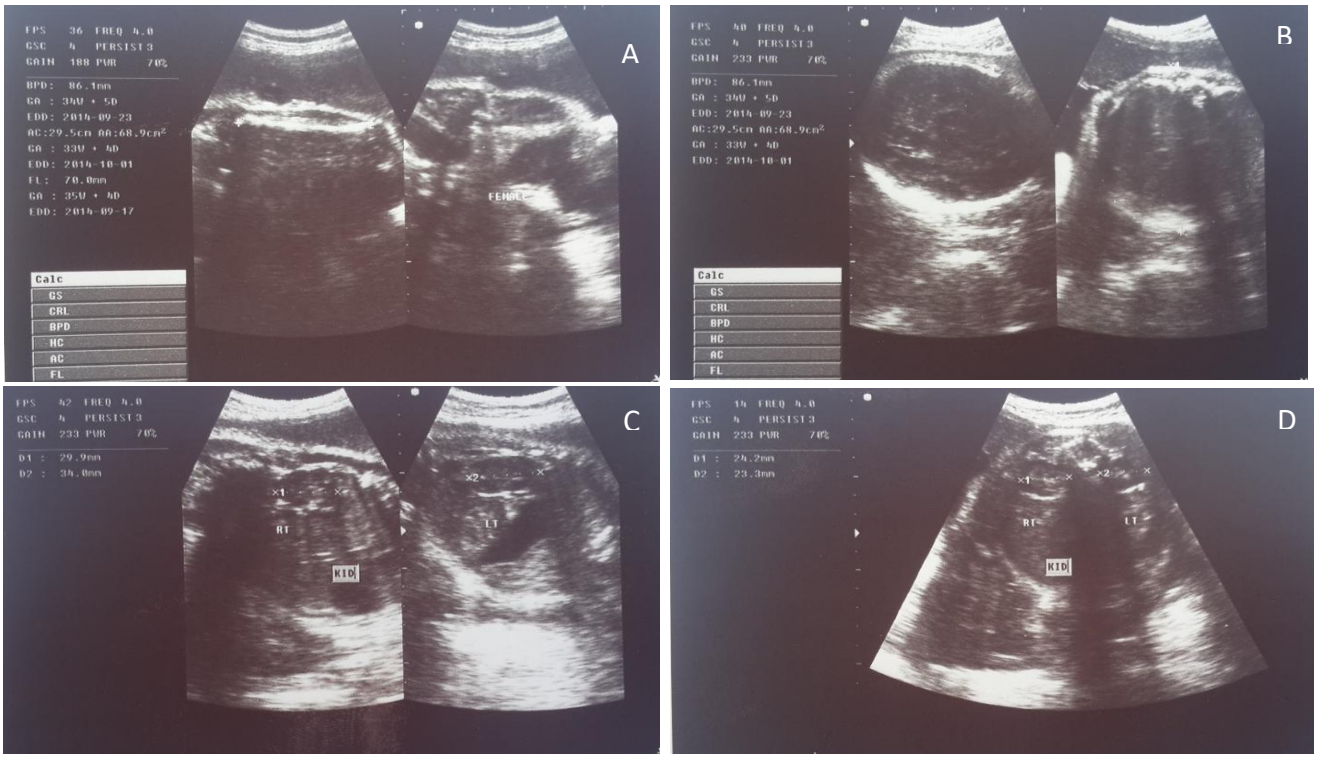

Figure 1: Sonographic measurements of the femur length (A), the biparietal diameter and abdominal circumference (B), the kidney length (C), and the kidney width (D) at the 34th week of gestation.

RESULTS

Out of 390 eligible women, 11 were excluded due to failure to clearly visualize and measured the fetal kidney, pregnancy-associated hypertension, diabetes mellitus, cardiac diseases, thyroid disease, repeated cesarean sections, or intrauterine fetal death. The majority of pregnant women fell within the age range of 25-35 years (Table 1). Regarding parity, most pregnant women had given birth to two children before the current pregnancy, while only two women had nine previous pregnancies (Table 2). When considering the residence distribution of the women in the study was taken into consideration almost 60% were from urban areas, while the remainder were from rural localities. In terms of occupation, the majority of women were housewives, followed by workers, and finally students. The socioeconomic situation of the cases in this study indicated that about 80% of the participants fell into the medium class, followed by low class, with very few (3%) in the high class. In 377 fetuses, both the right and left kidneys were adequately imaged and measured. The mean weight, height and BMI of the women were 70.4 kg (range, 52–100 kg), 1.64 cm (range, 82.00–195.00 cm), and 28.86 (range, 18.52–87.00), respectively (Table 1). There was no statistically significant difference between the measurements of the left and right kidneys concerning gestational age (weeks) and kidney width (mm), r = 0.84. A significant correlation was found between gestational Age (days) and kidney width (mm) (r = 0.67, P < 0000.000). The changes in mean kidney width at different gestational ages increased from 9.1 ± 1.5 mm at 16 weeks' gestation to 20.8 ± 2.9 mm at 40 weeks' gestation (Table 4, Fig. 2). The equations derived from linear regression analysis when the individual variables were considered separately showed that the most accurate parameter was the kidney width (KW) with a standard error (SE) of 0.02 days, followed by kidney length (KL) with an SE of 0.04 days, BPD with an SE of 0.10 days, and FL with an SE of 0.13 days. The most inaccurate was the abdominal circumference (AC) with an SE of 1.35 days (Table 4).

Table 1: Maternal ages of pregnant women between 15 -45 years

Maternal age (year)	Frequency	Percent
15 > 25	132	35.0
25 > 35	224	59.4
35 > 45	21	5.6
Total	377	100.0

Table 2: Parity distribution of cases.

Parity	Frequency	Percent
Primigravida	114	30.3
Multigravida	208	55.2
Grand multigravida	55	14.6
Total	377	100.0

Table 3: Maternal Weight, Height, and BMI of Pregnant Women

Anthropometric	Minimum	Maximum	Mean	Std. Deviation
Weight	52.0	100.0	70.4	8.0
Height	82.0	1.95	1.64	25.6
BMI	18.5	87.0	28.8	14.7

Table 4: Changes in Kidney Width with Gestation. Values (mm) are mean ± standard deviations.

Gestational age (weeks)	Mean Kidney Width (mm) (SD)
16	9.1 (1.5)
18	9.8 (1.3)
20	10.8 (0.7)
22	12.5 (1.4)
24	15.2 (3.5)
26	16.6 (4.7)
28	17.5 (3.0)
30	19.0 (2.9)
32	20.7 (2.3)
34	22.2 (4.0)
36	23.5 (3.2)
38	21.6 (3.5)
40	20.8 (2.9)

Table 5: Analysis of Fetal Biometric Parameters (FBP) using Linear Regression

Dependent Variable	Unstandardized Coefficients		Standardized Coefficients	P-value
	B	SE	Beta	
KW	0.607	0.024	0.673	.000
KL	0.982	0.035	0.718	.000
BPD	1.01	0.104	0.451	.000
FL	0.095	0.130	0.041	0.463
AC	0.825	1.35	0.034	0.541

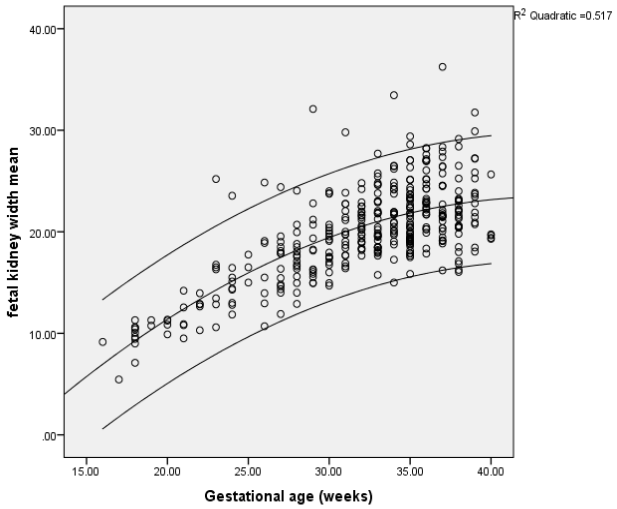

Figure 2: Scattergraphs of gestational age with fetal kidney width

DISCUSSION

Understanding the normal lengths of fetal kidneys is useful for diagnosing prenatal renal disorders. This is especially relevant if the echogenicity appears normal, as in certain early cases of polycystic kidney disease. Knowing normal renal length can aid in the early detection of nephromegaly or hypoplasia.[13] During early pregnancy, measuring the diameter and volume of the gestational sac, as well as the fetal crown-rump length, can accurately predict gestational age. Additionally, fetal BPD and femur length can be used during later gestational stages. Despite the fact that such biometric indices are inappropriate in the terminal stages of pregnancy, they continue to be used among women with uncertain LMP in late stages. Numerous studies have been conducted in this area, but none of their methods are practically used for gestational dating because the ultrasound dating method should be simple, easy to define, and reproducible. The current study assessed the role of fetal kidney width measurements in determining GA and compared their precision to other fetal biometric indices. The findings of this study showed that kidney width measurements, combined with additional fetal biometric parameters, can predict a pregnancy's age with a difference of approximately 0.02 days (difference). The advantage of this method is greater in the absence of BPD and/or HC measures due to the inability of ultrasonic assessment in the ideal planes or when the fetal head is positioned too low. In such cases, only kidney length can be used to estimate the age of pregnancy. Duval et al. reported challenges in imaging kidneys in breech and vertex

presentations with the back facing laterally or posteriorly.[14] However, no such problems were encountered in this study. A few adjustments of the transducer position and angle of insonation in relation to the kidney plane enabled easier determination of both kidneys, which is consistent with the findings of Konje et al.[11] There were no instances where both kidneys were unmeasurable. The mean BPD, FL, HC, and AC measurements throughout different gestations found in this study were consistent with those obtained by previous authors.[15,16] This study found that mean kidney length and fetal kidney width measurements at different gestations were also consistent with previous findings.[16,17] The variability of fetal kidney and other biometric measurements about the mean observed in our study was noticeably less than that reported in previous studies.[11,15,16,18-21] They reported no significant difference between left and right fetal kidney length measurements. The left fetal kidney length was slightly, but significantly, longer than the right fetal kidney length in studies conducted by others.[14,16,23] Their studies found the left fetal kidney length to be longer than the right fetal kidney length at the end of intrauterine life. In the present study, the mean left fetal kidney length was similar to the mean right fetal kidney length at each gestational period observed; there was no statistically significant difference between left and right fetal kidney length measurements. This finding is consistent with previous studies.[11,20,21] This study reveals a very strong correlation between fetal kidney width and GA as compared to previous studies. The correlation coefficient (r = 0.72) observed in the present study was lower than that reported by Schlesinger et al. (1987) (r = 0.859), Gloor et al. (1997) (r = 0.90), Chiara et al. (1989) (for right kidney r = 0.84, for left kidney r = 0.87), Konje et al. (2002) (r = 0.91), and Kaul et al. (2012) (r = 0.958).[11,16,20,22-24] The correlation coefficients between gestational age and other biometric indices were also lower compared to previous studies.[11] Several factors could explain these differences, including the type of study (longitudinal vs. cross-sectional), the quality of the ultrasonography machine (new vs. old), and the characteristics of subjects (only uncomplicated pregnancies vs. all pregnancies). Many authors reported no correlation between fetal kidney measurements and maternal age, height, weight, and parity.[24,25]

CONCLUSIONS

In conclusion, this study revealed that the most accurate was kidney width (KW) with a standard error (SE) of 0.02 days, followed by kidney length (KL) with an SE of 0.04 days, biparietal diameter (BPD) with an SE of 0.10 days, and femur length (FL) with a SE of 0.13 days. The least precise measurement was still the abdominal circumference (AC) with an SE of 1.35 days. A significant correlation was found between gestational age and KW ($r = 0.72$, $P < 0.002$). Kidney width is easy to identify and measure. Measuring kidney width can assist in the determination of gestational age, especially in cases where the date of the mother's last menstruation is unknown. Moreover, KW is the most accurate parameter for estimating GA compared to other biometric indices in the late second and third trimesters and should therefore be incorporated into future models for estimating GA.

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