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ULTRASONOGRAPHY OF FETAL KIDNEY LENGTH AS THE APPROACH FOR ESTIMATION OF GESTATIONAL AGE IN SUDANESE.

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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 was to evaluate the application of kidney length (KL) measurement to the determine GA between the 14th and 40th weeks and to compare its accuracy with that of other fetal biometric indices. This study has been designed as a prospective descriptive cross-sectional study in Khartoum and Gezira states - Sudan. 389 Sudanese healthy pregnant women, age between 15 – 45 years were examined by ultrasound with normal and well-being fetuses. Linear regression models for estimation of GA were derived from the biometric indices and kidney length. Also, stepwise regression models were constructed to detect the best model for determining GA between 14 and 40 weeks. Comparisons were then made between the accuracy of these models in the determination of GA. The equations derived from linear regression analysis when the individual variables were considered separately. Among the variable parameters considered in this study, the most accurate was the kidney length with a standard error (SE) of (0.04) day, after that the biparietal diameter with (SE=0.10 day) and femur length, (SE=0.13 day). While the least accurate one was the abdominal circumference with an SE of 1.35 days. A significant correlation was found between GA and KL (r=0.72, P<0.002). The Kidney length is the easy to identify and measure. It is the most accurate parameter for estimating GA than other biometric indices in late 2nd and 3rd trimesters.

Key words: Age estimation, Kidney length, Ultrasound, Radiograph and Sudan.

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INTRODUCTION

Accurate GA estimation is very important to an obstetrician for diagnosis of growth disorders, in assessment of wrong dates or forgotten dates and timing of delivery either by induction or cesarean section(Kalish and Chervenak, 2009). Likewise, the timing of repeat cesarean sections requires accurate assessment of dates(Kalish and Chervenak, 2009; Guideline, Of and Pregnancy, 2014). Ultrasound is a reliable method for establishing the length of pregnancy and in this way can improve obstetric care. Sonographically measured fetal renal length is an accurate and useful tool for assessment of fetal renal growth and well being(Abbas et al., 2012).
measurements is highly reliable in the first and second trimester of pregnancy but the reliability of any ultrasound method greatly diminishes as gestation advances. In the third trimester, the reliability of any single ultrasound parameter is poor. (Article et al., 2006; Pandey et al., 2015)

Ultrasound assessment for GA is becoming increasingly important. Many parameters are being used for establishing GA, for example, 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. In the past, the BPD had been described as a reliable method of determining GA. (Campbell, 1969; Mador et al., 2011). While the BPD was the first fetal parameter to be clinically utilized in the determination of fetal age 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 (Guariglia and Rosati, 2004; da Graca et al., 2013). However, as GA progresses, they become increasingly unreliable because of the biological variability of size in relation to age, (March, Warsof and Chauhan, 2012)

Accurate dating of pregnancies in the late second trimester or the third trimester, therefore, remains a problem, especially in women who consult late for maternity care and are uncertain of the date of their LMP. Fetal kidney grows progressively along with GA and, therefore, ultrasonography examination can predict GA at any trimester. Parameters such as BPD etc. are thought to compute GA more correctly when performed at an earlier gestation (Shaikh and Lombay, 2004).

The fetal kidney is easy to identify and measure, (Konje et al., 2002; Geelhoed et al., 2009) but has not been studied extensively as a biometric index for GA estimation, although ultrasound textbooks often have tables of different dimensions. In this prospective study, we evaluated the accuracy and reproducibility of kidney length measurements in the prediction of GA in the second and third trimester of pregnancy in which the kidneys were accurately measured. Also, we compared the accuracy of this method with that using BPD, HC FL.

**MATERIALS AND METHODS**

This study has been designed as a prospective cross-sectional (observational) study in Khartoum and Gezira states – Sudan. The fetal kidneys of 389 pregnant women examined at various stages of pregnancy at Al Saudi Maternity Teaching Hospital, Wadmedani Military Hospital (Department of Radiology and Imaging).

The study population consisted of 389 pregnant Sudanese women who were between (14 and 40) weeks gestational age and referred to an obstetric clinic. Aged between (15 – 45) years, all women who satisfied the inclusion criteria stated to this study as regular menstrual cycle with certainty about the time of the last menstrual period, normal pregnancy, and viable singleton were included in the study population. On the other hand, the study excluded those unsure of accurate memory of last menstrual period, congenital fetal abnormalities, inability to clearly image/measure fetal kidney, pregnancy including hypertension, diabetes mellitus, heart disease, thyroid disease, repeat caesarean section, intrauterine fetus death, chronic kidney disease and renal failure. The study population, representing different Sudanese tribes, was limited to the states of
Khartoum and Gezira. All examinations and ultrasound measurements were performed in the hospitals using standardized trans-abdominal techniques. Only kidneys whose outline was complete could be imaged. Unclear adrenal or renal borders, abnormal renal morphology, and renal pelvic dilatation greater than 4 mm in anteroposterior diameter were grounds for excluding the measurement. We used the last criteria, despite the fact that dilatations as great as 1 cm may be found in fetuses who at birth have no evidence of renal obstruction or vesicoureteral reflux because we wished to avoid any suggestion of falsely long kidney measurements due to dilatation.

The measurement of the BPD is made in the transverse axial plane. Intracranial landmark utilized for the BPD include visualization of the falx cerebri posteriorly, the cavum septipellucid anteriorly and paired thalami in the midline with a Sylvian fissure laterally. The FL was measured with the bone a cross the beam axis. The strong acoustic shadow behind the femoral shaft and the visualization of both cartilaginous ends indicated the image plane is on the longest axis.

These lengths of kidneys were analyzed about GA determined by examined each case in the supine position. Multiple cross sections of the uterus made in longitudinal and transverse directions. In the course of ultrasonography, the fetal position and biparietal diameter (BPD) were determined. These lengths of kidneys were analyzed in relation to gestational ages determined on the basis of biparietal diameter (BPD), femoral length (FL), abdominal circumference (AC), and an average of those three gestational ages in weeks, which we termed average weeks.

The longest renal lengths also were assessed in relationship to maternal heights, weights, BMI, and age. All data (mean±standard deviation) were analyzed with SPSS Statistical Package for Social Sciences (SPSS) software (version 16; SPSS Inc, Chicago, IL, USA). A p-value less than 0.05 was considered as statistically significant. The research and ethics committee of Ministry of Health, Khartoum State Sudan approved the study.

RESULTS

Out of 389 eligible women completed the study. 12 were excluded because of failure to clearly visualized/measures the fetal kidney, pregnancy-associated hypertension, diabetes mellitus, cardiac diseases, thyroid disease, repeated cesarean sections or intrauterine fetal death. In 377 fetuses, both the right and left kidney were imaged adequately and measured. The mean, weight, height and BMI of the women were, 70.4 (range, 52 –100) kg, 1.64 (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 between gestational age (weeks)
and kidney length (mm), $r = 0.83$. A significant correlation was found between Gestational age (days) and kidney length (mm) ($r=0.72$, $P<0.000$). The changes in mean kidney length at different gestational ages increased from $16.9 \pm 0.28$ mm at 16 weeks’ gestation to $38.8 \pm 3.4$ mm at 40 weeks’ gestation. Table 2.

The equations derived from linear regression analysis when the individual variables were considered separately. The most accurate was the KL with a standard error (SE) of 0.04 day, after that BPD (SE=0.10 day) and FL (SE=0.13 day). While the most inaccurate was the AC with an SE of 1.35 days, table 3.

Table 1: Maternal weight, height, and BMI of pre

<table>
<thead>
<tr>
<th>Anthropometric</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>52.0</td>
<td>100.0</td>
<td>70.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Height</td>
<td>82.0</td>
<td>1.95</td>
<td>1.64</td>
<td>25.6</td>
</tr>
<tr>
<td>BMI</td>
<td>18.5</td>
<td>87.0</td>
<td>28.8</td>
<td>14.7</td>
</tr>
</tbody>
</table>

Table 2: Changes in kidney length with gestation. Values (mm) are mean ± standard deviations.

<table>
<thead>
<tr>
<th>Gestational age (weeks)</th>
<th>Mean kidney length T±(SD) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>16.9(.28)</td>
</tr>
<tr>
<td>18</td>
<td>17.1 (2.6)</td>
</tr>
<tr>
<td>20</td>
<td>17.3 (1.8)</td>
</tr>
<tr>
<td>22</td>
<td>26.5 (2.2)</td>
</tr>
<tr>
<td>24</td>
<td>28.0 (6.8)</td>
</tr>
<tr>
<td>26</td>
<td>26.9(6.6)</td>
</tr>
</tbody>
</table>

Table 3: Linear regression analysis of fetal biometric parameters.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPD</td>
<td>1.01</td>
<td>0.451</td>
<td>0.000</td>
</tr>
<tr>
<td>FL</td>
<td>0.095</td>
<td>0.041</td>
<td>0.463</td>
</tr>
<tr>
<td>AC</td>
<td>0.825</td>
<td>0.034</td>
<td>0.541</td>
</tr>
</tbody>
</table>


Figure 2. Scattergraphs of gestational age with kidney length.

DISCUSSION

It is helpful to know normal lengths of fetal kidneys to diagnose fetal renal abnormalities. This is particularly true if the echogenicity is apparently normal, which may occur in some early cases of polycystic disease of the kidney. Knowledge of normal renal length can be helpful in early determinations of nephromegaly or hypoplasia (Yusuf, Moslem and Haque, 2007).
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 BPD and length of the femur can be used during the later gestational stages. 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. The fetal kidney is easy to identify and measure, but has not been studied extensively as a biometric index for gestational age estimation, although ultrasound textbooks often have tables of different dimensions (J.J. Miranda et al., 2009 & Konje, J. C. et al. 2002).

In the present study we evaluated the role of FKL measurements in the estimation of GA and compared its accuracy with other fetal biometric indices, our findings showed that KL measurements combination with other fetal biometric parameters could predict the age of pregnancy within 0.04 days. Duval and his colleagues (Duval et al., 1985) encountered difficulty in imaging kidneys in breech presentation and in vertex presentations with back facing laterally or posteriorly. However, no such difficulty was experienced in the present study. A little manipulation of the transducer position and angle of insonation relative to the kidney plane allowed easy identification of both kidneys which is in agreement with Konje and his colleagues (Konje et al., 2002). There was no case in which both kidneys were not measurable.

The mean BPD, FL, HC and AC measurements at various gestations observed in our study were similar to measurements obtained by previous authors O’Brien et al. and Kaul et al.(O’Brien and Queenan, 1981; Kaul et al., 2012) The mean KL measurements at various gestations observed in our study were similar to measurements obtained by Abdelmoneim et al (Sulieman and Sattam, 2013) and Kaul et al(Kaul et al., 2012). The variability of the FKL and other biometric measurements about the mean observed in our study was noticeably less than that observed in previous studies done by Konje et al.(Konje et al., 2002), Hohler et al(Hohler, 1984), O’Brien et al.(O’Brien and Queenan, 1981), Kaul (Kaul et al., 2012), Lyn et al.(Chitty and Altman, 2003).

Many authors, Konje et al. (Konje et al., 2002), Schlesinger et al. (Schlesinger et al., 1987) and Shin et al. (Shin et al., 2007) reported no significant difference between left and right FKL measurements. Left FKL was slightly but significantly longer than right FKL in the Fitzsimons et al study. (Fitzsimons, 1983). Kaul et al. (Kaul et al., 2012), Duval et al. (Duval et al., 1985) and Sampaio et al. (Sampaio, Mandarim-de-Lacerda and Prates, 1989) in their study found left FKL to be longer than right FKL at the end of intrauterine life. In the present study, the mean left FKL was similar to the mean right FKL at each gestational period observed in the study, there was no statistically significant difference between left and right FKL measurements. This finding was consistent with the study of Konje et al.(Konje et al., 2002) Schlesinger et al(Schlesinger et al., 1987) and Shin et al(Shin et al., 2007). We found a very strong correlation between FKL and GA as compared to previous studies. The correlation coefficient (r=0.83) observed in present study was less as compared to Schlesinger et al (1987) (r=0.859), Gloor et al (1997) (r=0.90), Chiara et al (1989) (for RK r=0.84, for LK r=0.87), Konje et al (2002) (r=91), and Kaul et al (2012)(r=0.958),(Schlesinger et al., 1987; Chiara et al., 1989; Gloor et al., 1997; Konje et al., 2002; Kaul et al., 2012). Correlation coefficients between GA and other biometric indices were also less as compared to previous studies (Konje et al., 2002). Some reasons could explain these differences. These include the type of study (longitudinal vs. cross-sectional), quality of
ultrasonography machine (new vs. old) and characteristics of subjects (only uncomplicated pregnancies vs. all pregnancies). Regarding FKL increase at a constant rate of about 1.7 mm every two weeks throughout pregnancy in Turkey (Ugur MG Kaul et al., 2016) in another Pakistani study involving 399 participants with pregnancies between 20 and 38 weeks, found that right kidney length increased by 1.75 mm with each week of gestation (Akram MS et al., 2019). FKL grew at a rate of 1.164 mm per gestational week (A.O, Akintomide et al., 2022). In accordance with the current study result, the FKL increases by 1.9 every two weeks. Many authors reported no correlation was found between FKL and mother’s age, height, weight, and parity (Sulieman and Sattam, 2013). In the present study the observations we found a correlation between fetal kidney length and mother’s age and Caesarian section group (P < 0.002).

CONCLUSION

From this study we could find that the most accurate method for evaluation of GA was the kidney length with a standard error (SE) of 0.04 day, followed by biparietal diameter (SE=0.10 day) and finally femur length (SE=0.13 day). While the most inaccurate method for estimation of GA was the abdominal circumference with a standard error of 1.35 days. Kidney length is easy to identify and measure. Measuring of kidney length can help in the determination of gestational age, especially in cases where the date of the mother’s last menstruation is unknown. Moreover, KL is most accurate parameters for estimating GA in comparison to other biometric indices in late 2nd and 3rd trimester and should be therefore be incorporated into the future models for estimating GA.

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CONFLICTS OF INTEREST

The authors affirmed that there are not any conflicts of interest.

REFERENCES