ORIGINAL COMMUNICATION

Anatomy Journal of Africa. 2022. Vol 11 (2):2167-2174

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

∗Mohamed O. Mustafa[1], Qurashi. M. Ali[2], Mohamed Haleeb[3], Kamoleldin Badawey[4], Mohammed A.A.Abdelmotalab[5]

[1]Assistant professor at Department of Anatomy, University of Gadarif
[2]Professor at Department of Anatomy, National University
[3]Radiologist at Wadmedani Military Hospital Department of Radiology and Imaging
[4]Professor at Department of Anatomy, National Ribat University
[5]Assistant professor at Department of Anatomy, National University of Africa
Correspondence to: Mohammed Omer Mustafa. Email: m.omer960.mo@gmail.com

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.

DOI: https://dx.doi.org/10.4314/aja.v11i2.3

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).

Fetal growth assessment, either clinically or by ultrasound evaluation, also relies on accurate assessment of GA. Obstetric management is also dependent on GA. The proper decision regarding presumed preterm labor or postdate pregnancies are only possible when GA is accurately estimated. 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) Ultrasonography of fetal

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 bipanietal 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.

Figure 1. Sonographic measurements of the kidney length at 36th week of the gestation.

RESULTS

Out of 389 eligible women completed the study. 12 were excluded because of failure to clearlyvisualized/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 ± .28 mm at 16 weeks' gestation to 38.8 ± 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

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

Gestational age (weeks)	Mean kidney length T± (SD) (mm)
16	16.9(.28)
18	17.1 (2.6)
20	17.3 (1.8)
22	26.5 (2.2)
24	28.0 (6.8)
26	26. 9(6.6)
28	30.0(3.9)
30	31.4 (4.0)
32	35.0(5.1)
34	36.3 (3.7)
36	37.6 (4.9)
38	37.8 (3.8)
40	38.8 (3.4)

Table 3: Linear regression analysis of fetal biometric parameters.

Dependent Variable:	Unstandardized Coefficients		Standardized Coefficients	*P* value
	B	SE	Beta	
BPD	1.01	0.104	0.451	0.000
FL	0.095	0.130	0.041	0.463
AC	0.825	1.35	0.034	0.541

Constant : gestational age. Dependent Variable : AC: abdominal circumference; BPD: biparietal diameter; FL: femur length.

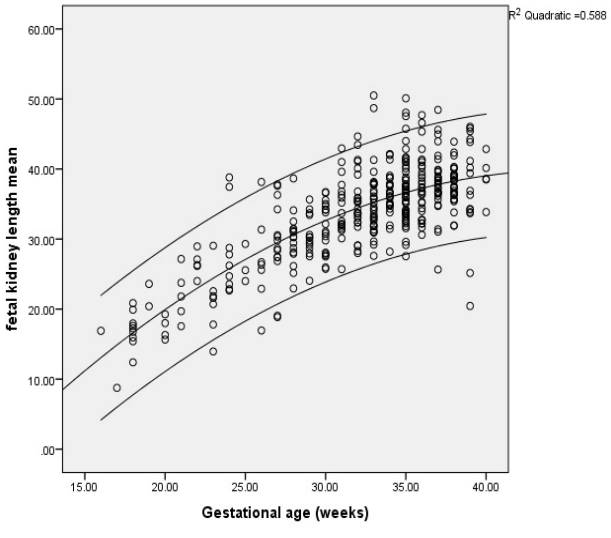

Figure 2. Scattergraphs of gestational age with kidney length

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 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, andparity (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.

ACKNOWLEDGEMENTS

With immense gratitude that we acknowledge the staff of the Department of Radiology in Al Saudi Maternity Teaching Hospital and Wad- Medani Military Hospital for their continuous help and support in data collection and maintainces

CONFLICTS OF INTEREST

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

REFERENCES

1. Abbas, F. et al. (2012) 'comparative study of manual and ultrasonographic measurement of fetal renal length', 10(1).
2. Article, R. et al. (2006) 'Fetal biometry', 22(4), pp. 503–508.
3. Akram MS, Yousaf M, Farooqi U, Arif N, Riaz A, Khalid M, et al. Estimation of gestational age from fetal kidney length in the second and third trimester of pregnancy by ultrasonography. Saudi J Med Pharm Sci 2019;5:222-9.
4. A.O, Akintomide & Effanga, Samuel. (2022). Fetal Kidney Length: A Likely Sole Index for Gestational Age Determination in Late Pregnancy and Certain Abnormalities. Nigerian Journal of Medicine. 31. 10.4103/NJM.NJM_199_21.
5. Campbell, S. (1969) 'The prediction of fetal maturity by ultrasonic measurement of the biparietal diameter.', The Journal of obstetrics and gynaecology of the British Commonwealth. England, 76(7), pp. 603–609.
6. Chiara, A. et al. (1989) 'Ultrasonic evaluation of kidney length in term and preterm infants.', European journal of pediatrics. Germany, 149(2), pp. 94–95.

7. Chitty, L. S. and Altman, D. G. (2003) 'Charts of fetal size: kidney and renal pelvis measurements.', Prenatal diagnosis. England, 23(11), pp. 891–897. doi: 10.1002/pd.693.
8. Duval, J. M. et al. (1985) 'Ultrasonographic anatomy and physiology of the fetal kidney.', Anatomia clinica. Germany, 7(2), pp. 107–123.
9. Fitzsimons, R. B. (1983) 'Kidney length in the newborn measured by ultrasound.', Acta paediatrica Scandinavica. Sweden, 72(6), pp. 885–887.
10. Geelhoed, J. J. M. et al. (2009) 'Tracking and determinants of kidney size from fetal life until the age of 2 years: the Generation R Study.', American journal of kidney diseases : the official journal of the National Kidney Foundation. United States, 53(2), pp. 248–258. doi: 10.1053/j.ajkd.2008.07.030.
11. Gloor, J. M. et al. (1997) 'Fetal renal growth evaluated by prenatal ultrasound examination.', Mayo Clinic proceedings. England, 72(2), pp. 124–129. doi: 10.1016/S0025-6196(11)63472-1.
12. da Graca, A. L. F. M. et al. (2013) 'Assessment of gestational age using cerebellar measurements at cranial ultrasound: what is the best approach?', Early human development. Ireland, 89(1), pp. 1–5. doi: 10.1016/j.earlhumdev.2012.07.008.
13. Guariglia, L. and Rosati, P. (2004) 'Evaluation of femur/foot and humerus/foot ratios by transvaginal sonography between 62 and 116 days of gestation.', Archives of gynecology and obstetrics. Germany, 270(3), pp. 147–150. doi: 10.1007/s00404-003-0531-8.
14. Guideline, C. P., Of, M. and Pregnancy, M. (2014) 'clinical practice guideline management of multiple pregnancy Institute of Obstetricians and Gynaecologists , Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Care , Health Service Executive Guideline No . 14 Date of publicat', (14), pp. 1–14.
15. Hohler, C. W. (1984) 'Ultrasound estimation of gestational age.', Clinical obstetrics and gynecology. United States, 27(2), pp. 314–326.
16. Kalish, R. B. and Chervenak, F. (2009) 'cme sonographic determination of gestational age', 59(2), pp. 202–208.
17. Kaul, I. et al. (2012) 'Role of Fetal Kidney Length in Estimation of Gestational Age', 14(2), pp. 65–69.
18. Konje, J. C. et al. (2002) 'Determination of gestational age after the 24th week of gestation from fetal kidney length measurements.', Ultrasound in obstetrics & gynecology : the official journal of the International Society of Ultrasound in Obstetrics and Gynecology. England, 19(6), pp. 592–597. doi: 10.1046/j.1469-0705.2002.00704.x.
19. Mador, E. S. et al. (2011) 'Ultrasonographic biometry: Biparietal Diameter of Nigerian foetuses.', Nigerian medical journal : journal of the Nigeria Medical Association. Nigeria, 52(1), pp. 41–44.
20. March, M. I., Warsof, S. L. and Chauhan, S. P. (2012) 'Fetal biometry: relevance in obstetrical practice.', Clinical obstetrics and gynecology. United States, 55(1), pp. 281–287. doi: 10.1097/GRF.0b013e3182446e9b.
21. O'Brien, G. D. and Queenan, J. T. (1981) 'Growth of the ultrasound fetal femur length during normal pregnancy. Part I.', American journal of obstetrics and gynecology. United States, 141(7), pp. 833–837.
22. Pandey, V. D. et al. (2015) 'Fetal Foot Length for Assessment of Gestational Age : A Comprehensive Study in', 3, pp. 139–144.
23. Sampaio, F. J., Mandarim-de-Lacerda, C. A. and Prates, J. C. (1989) 'Allometric study of renal growth in human fetuses.', Surgical and radiologic anatomy : SRA. Germany, 11(1), pp. 29–31.

24. Schlesinger, A. E. et al. (1987) 'Normal standards for kidney length in premature infants: determination with US. Work in progress.', Radiology. United States, 164(1), pp. 127–129.
25. Shaikh, M. S. and Lombay, B. (2004) 'Fetal MRI : reviewing the history, indications, technique, safety and drawbacks.', Journal of the College of Physicians and Surgeons--Pakistan : JCPSP. Pakistan, 14(9), pp. 576–579. doi: 09.2004/JCPSP.576579.
26. Shin, J. S. et al. (2007) 'Nomogram of fetal renal growth expressed in length and parenchymal area derived from ultrasound images.', The Journal of urology. United States, 178(5), pp. 2150–2154. doi: 10.1016/j.juro.2007.07.044.
27. Sulieman, A. and Sattam, P. (2013) 'The Normal Fetal Kidney Measurement in in Normal Pregnant Ladies', (January 2014).
28. Ugur MG, Mustafa A, Ozcan HC, Tepe NB, Kurt H, Akcil E, et al. Fetal kidney length as a useful adjunct parameter for better determination of gestational age. Saudi Med J 2016;37:533-7.
29. Yusuf, N., Moslem, F. and Haque, J. A. (2007) 'Fetal Kidney Length : Can be a New Parameter for Determination of Gestational Agein 3rd Trimester', 20(2).