Medicina Interna: Open Access (MI)

Research Article

Prenatal Ultrasound Evaluation of Foetal Kidney Length in A Nigerian Population.

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Abstract

Statement of the problem: There are so many methods of determining foetal age. This is an innovation in determining gestational age of foetus. It is safe and result is reliable. Aim: This was to determine the relationship between gestational age and longest bipolar kidney length. To establish a baseline normal values of kidney length in-utero, and to compare the mean foetal kidney length of the subjects studied with other known biometric parameters and that of the Caucasians. Methodology: The kidney lengths of 247 foetuses between 20 and 40 weeks gestational age in normal singleton pregnancies were measured sonographically.

Findings: Results indicate that the kidney lengths range from 2.0cm to 4.2cm. Growth rate was fastest between 25 - 28weeks. There was positive correlation between gestational age and mean renal length. The two variables are linearly related and the regressional analysis is represented by the equation Y(GA) = 7.9098(RL) + 3.973. There was also positive correlation between foetal renal length and other biometric parameters like biparetal diameter (BPD), femoral length (FL), abdominal circumference (AC) and transverse abdominal diameter (TAD). Renal lengths in Nigerian foetuses at different gestational ages exhibited similar linear increase in length to that of the Caucasians.

Conclusion: This showed that as the gestational age increases, the mean renal length also increases for both groups. The measurement is easy to make and could therefore be easily incorporated into the model for dating pregnancies using the equation Y(GA) = 7.9098(RL) + 3.973. However, the normal values of the mean renal length were significantly different for both races. The values were consistently shorter for our foetuses compared with earlier reports in Caucasians but are consistent with neonatal measurements in some published studies. It was concluded that the nomogram from this study has provided the needed baseline data on normal foetal kidney length in this locality and that fetal renal length is linearly related to fetal gestational age. The study also showed that racial difference exists in foetal kidney length in-utero.

Keywords: *Prenatal Ultrasound, Foetal Kidney Length, Nigerian Population*

Introduction

Accurate knowledge of gestational age is the key to successful antenatal care of patients. It is very critical in interpretation of antenatal tests and the successful planning of appropriate treatment or intervention. Foetal development is assessed sonographically by biometric measurements of different foetal body parts. Various ultrasonic parameters commonly used to estimate the gestational age are the biparietal diameter (BPD), head circumference (HC), femur length (FL), Transverse abdominal diameter (TAD) abdominal circumference (AC) among others. However, while these parameters are reliable in the early second trimester, they are not as reliable in the late second and third trimester scans especially in cases with intrauterine growth restriction [1]. The composite gestational age prediction in the third trimester does not give with great accuracy the actual gestational age taking into consideration the discrepancies of late trimester scan and possibility of growth restriction [1]. Thus, there is the need to explore other biometric parameters to increase accuracy in ultrasound dating during these affected periods especially in patients with wrong dates, unknown last menstrual period (LMP), with late antenatal registration and pregnancies compounded with intrauterine growth restriction [2].

A number of methods including foetal kidney length may be employed to determine an accurate gestational age. Unfortunately, the last menstrual period (LMP) cannot be used for all patients because 10 to 40% of all patients seen in the antenatal clinics have no knowledge of their LMPs. This was probably due to history of irregular menstrual cycles or usage of oral contraceptives within two months of their LMP [2]. Ultrasound has the capacity of imaging the foetal kidneys by transabdominal scan after eighteen (18) weeks of gestation [3]. At this gestational age there is presence of adequate amount of amniotic fluid necessary to clearly visualize the foetal kidneys. Therefore, it is appropriate to assess foetal kidney length from second trimester of gestation. This is because adequate amniotic fluid volume provides good perifoetal acoustic window to clearly visualize the foetal kidneys.

Moreover, foetal organ measurements may allow early in-utero detection of numerous foetal abnormalities. Routine use of ultrasonography has become more prevalent since the past decade allowing for urologists and pediatricians alike to be informed of possible kidney defects before birth. These abnormalities may present as foetal organ enlargement or deformities of varying degrees. Reduced or enlarged foetal kidneys have been associated with a number of chronic or acute urinary tract disease conditions. Some of these urinary tract abnormalities include Finnish syndrome, infantile polycystic kidney, Merckel's syndrome and posterior urethral valve obstruction. Some of these urinary tract abnormalities are invariably fatal. It is important to note that most of these developmental anomalies and diseases of the kidney have effect on renal size. It is

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Received: April 04 2018; **Accepted:** April 24, 2018; **Published:** April 27, 2018.

a worthwhile attempt to recognize such gross anomalies prior to 22 weeks foetal age so that therapeutic abortion can be performed [4]. Thus, estimation of foetal gestational age using these abnormal foetal body parts will lead to wrong foetal gestational age. For instance, in a case of achondroplasia (a type of dwarfism characterized by a bulging forehead and short limbs), biparietal diameter (BPD) will give a higher gestational age while femoral length (FL) will give very low gestational age [5]. In marked enlargement of the cerebral ventricles (Hydrocephalus), biparietal diameter will give a higher gestational age as well. In cases of anencephaly where foetal cranium is absent, measurement of biparietal diameter is unrealistic and therefore gestational age estimation can only be achieved using femur length or other parameters.

Therefore, the need to utilize a biometric parameter where it has a comparative advantage over multiple parameters has been found to improve prediction accuracy of the procedure of in-utero gestational age estimation.

It is factual that foetal kidney length can be readily measured ultrasonographically but the baseline values for estimation of gestational age remains subjective without the use of appropriate standard [4]. Therefore, establishing a standard for determining gestational age by foetal kidney length will be clinically useful.

Moreover, published data on normal values of foetal renal lengths are limited and have been based on Caucasian population group. Therefore, using this Caucasian nomogram in taking critical clinical decisions on foetal gestational age and assessing the existence of anomalies in a Nigerian population may lead to erroneous conclusions.

Ozo et al, [6] and Ukoha et al, [7] noted that racial differences exist in renal parameters in the adult population and this cannot be over looked in the prenatal population.

This work is therefore aimed at establishing baseline normal reference values of prenatal foetal kidney length and to evaluate its relationship with gestational age in normal pregnant Nigerian women.

Objectives of the study

To evaluate the relationship between foetal renal length and Gestational Age in our local population.

To sonographically establish baseline normal reference values of prenatal foetal kidney length (FKL) in normal single pregnancies in a Nigerian population.

To compare the accuracy of the foetal kidney length in estimation of gestational age with the existing established biometric parameters such as femoral length, transverse abdominal diameter, biparietal diameter among others.

To compare the mean foetal kidney length of the subjects studied with that of the Caucasians.

Material and methods

Research design:

A cross-sectional prospective design was adopted for this study. All the pregnant women for the routine second and third trimester obstetric ultrasound scan at Nnamdi Azikiwe University Teaching Hospital Nnewi were enlisted into the study.

Target population:

The target population for this study was all pregnant Nigerian women between 20 and 40 weeks of gestation, who were referred for obstetric ultrasonography at the hospital.

Sampling method:

The subjects who met the inclusion criteria and accepted to participate were recruited and scanned as they present for obstetric ultrasonography in the center.

Inclusion and exclusion criteria

Subjects were included in the study if:

(i) She is a Nigerian citizen.

(ii) She was carrying singleton pregnancy during the time of the study.

(iii) Complete outline of the foetal kidneys could be visualized from the sonographic image.

Subjects were excluded from the study if:

(i) There was evidence that the foetus was large-for-date or small for date.

(ii) There was evidence of oligohydramnois or polyhydroamnois.

(iii) There was significant discrepancy between postmenstrual age and gestational age estimated from biometric measurements.

(iv) There was abnormal renal morphology and renal pelvic dilatation greater than 4mm in anteroposterior diameter. This will give undue higher values due to abnormal increase in the kidney size as a result of the dilatation.

(v) The mother of the foetus was diabetic or was infected with human immunodeficiency virus as will be indicated in the referring request form.

Data collection:

On arrival at the ultrasound room the procedure was clearly explained to the subject and an informed consent obtained from her before recruitment into the study. If she met all the inclusion criteria, obstetric sonography was then carried out on her and measurement of the foetal kidneys taken.

Equipment used:

Obstetric ultrasound scan was carried out on each subject included in the study using Toshiba Core vision ultrasound equipment with 3.5MHz curvilinear transducer. The machine has electronic cursor, Doppler facilities, printer, memory and zoom facilities.

Scanning technique:

Transabdominal scan: No special pre-scan preparation was required. The subject was placed in supine position and the abdomen carefully exposed and covered with adequate ultrasound coupling gel. Scanning then commenced. The foetus was visualized and carefully inspected to make sure that it met the inclusion criteria. The transducer was moved over the foetal abdomen to create a longitudinal image of the abdomen in which the maximum bipolar diameter of the kidneys could be seen. The maximum bipolar diameter of the kidney closer to the transducer was measured using paravertebral position in a longitudinal scan as a reference point. This is to avoid magnification if the distal kidney is used. The measurements were taken from the outer to outer hyperechoic margins as explained by Harris et. al, [8] and shown in figure 1.

Biparietal diameters and transabdominal diameters were measured to estimate gestational age and foetal weight according to Hansman's method. The ultrasound coupling gel was then wiped off and the subject helped off the couch.

Data analysis:

The data collected were analyzed using Microsoft's™ Statistical

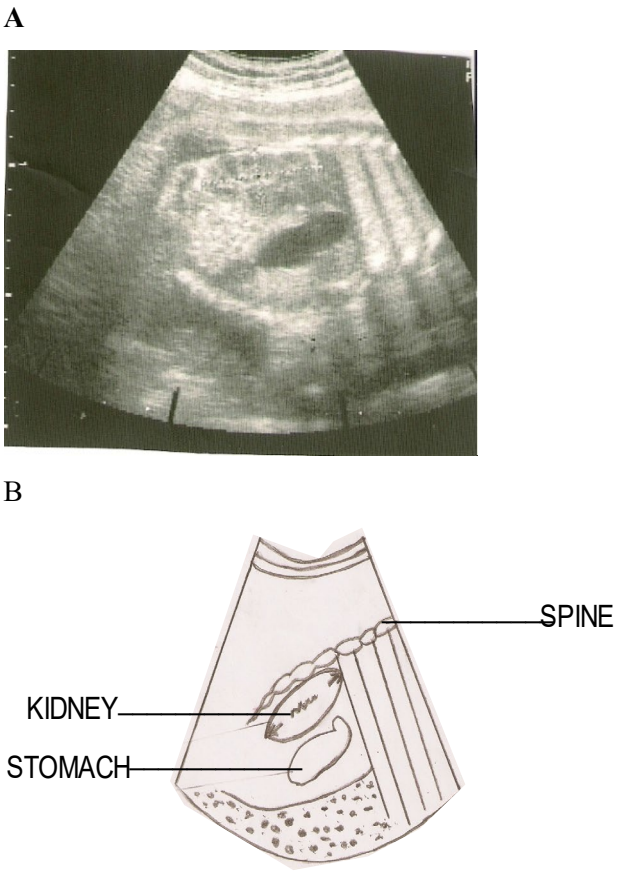

Figure 1: (a) Sonogram of the paravertebra position of prenatal foetal kidney at 36 weeks gestational age (Longitudinal view). (b) Annotated diagram of the Sonogram.

Package for Social Sciences (SPSS) version 20. The distribution of foetal renal length with values expressed as mean ± standard deviation according to gestational age (in weeks) was obtained and a nomogram established.

Correlation analysis was done using Pearson's method to establish the relationship between mean renal length and gestational age as well as to estabilish the relationship between mean renal length and biparietal diameter (BPD), femur length (FL) and transverse abdominal diameter (TAD).

Regression analysis was used to plot the linear graph of the relationship between mean renal length and gestational age in weeks.

Growth rate of the foetal kidney length per week was calculated using the formula:

Growth rate = increase in length/ Gestational age

Analysis of variance (ANOVA) was used to determine the significance of statistical differences in mean renal lengths between gestational ages at 0.05 level of significance.

The Z score for normal distribution was used in comparing the measured mean value of the foetal renal length in this locality and the mean value of that of Caucasians. Statistical significance was considered at $\rho < 0.05$.

Results

Table 1 Variation of Fetal Renal Length with Gestational Age. Gestational ages as shown in the table are average of the gestational ages (in weeks) determined on the bases of biparietal diameter (BPD), femur length (FL) and transverse abdominal diameter (TAD). It shows linear increase of the biometric parameters in relation to foetal gestational age. There is latent period of growth from 20 to 24 weeks where growth rate is consistently 0.1cm during these weeks. Fastest growth period is seen as from 25 to 28weeks with growth rate of 0.12. Latent period of fetal renal increase is also seen towards term with growth rate of 0.1cm.

Table 1: Variation of Fetal Renal Length with Gestational Age.

Gestational Age (Weeks)	No. of Measurements	Range	Mean Rental Length (cm)	Growth Rate	Standard Deviation
20	13	1.8-2.1	2.0	0.1	0.2
21	12	1.7-2.3	2.1	0.1	0.2
22	9	2.2-2.7	2.2	0.1	0.2
23	17	2.0-2.6	2.3	0.1	0.2
24	12	2.4-3.0	2.4	0.1	0.2
25	11	2.3-3.2	2.5	0.12	0.2
26	16	3.0-3.4	3.2	0.12	0.2
27	19	3.0-4.2	3.3	0.12	0.3
28	6	2.7-4.0	3.4	0.12	0.4
29	10	2.5-3.8	3.5	0.11	0.5
30	12	3.2-4.2	3.4	0.10	0.3
31	11	3.2-4.2	3.5	0.11	0.3
32	5	3.4-4.1	3.6	0.10	0.3
33	11	3.5-4.2	3.4	0.11	0.3
34	12	3.9-5.0	4.0	0.11	0.3
35	14	4.0-5.2	4.0	0.10	0.5
36	9	4.0-4.7	4.0	0.11	0.5
37	16	3.7-4.7	4.1	0.11	0.3
38	14	2.4-5.1	4.2	0.11	0.7
39	8	3.8-5.4	4.2	0.11	0.5
40	10	3.9-4.5	4.2	0.11	0.2

Regression equation for gestational age against renal length is given below as

$Y(GA)=7.9098(RL)+3.973$.....1,

where GA is gestational age in weeks and RL is renal length in centimeters. The intercept on the Y axis = 7.9098. The coefficient of regression (3.973) is positive. This shows that the two variables Y(GA) and X(RL) tend to change (increase) in the same direction. The linear equation can be used to estimate gestational age from foetal renal length.

Strong relationship is noted between the observed renal length and the predicted values of the dependent variable gestational age ($r = 0.954$, $\rho < 0.05$). In other to estimate how well the model fits the population, r^2 is considered ($r^2 = 0.909$), this indicates that the model fits the data well. However, analysis of variance (ANOVA) showed significant differences in mean renal length at various gestational ages studied. This implies that foetal renal length can be used to predict gestational age.

Table 2 shows there was linear increase in mean renal length with biparietal diameter (BPD), femur length (FL) and transverse abdominal diameter (TAD). There was a similar relationship between mean renal length and estimated foetal weight.

The correlation analysis shows strong positive correlation between foetal renal length and other biometric parameters.

The present study exhibited similar linearity growth trend to the Caucasians but the numerical values are different.

The Z score showed that there was significant difference between the Caucasian values of mean foetal renal length at various gestational ages and values obtained in the present study ($\rho < 0.05$). Table 3

Table 2: Relationship Between Biometric Parameters, Mean Foetal Renal Length and Expected Foetal Weight At Various Gestational Ages.

BPD (cm)	FL (cm)	TAD (cm)	Mean Renal Lgth. (cm)	Mean GA Wks	Std. Dev.	EfW (kg)
4.5	2.9	4.3	2.0	20	0.2	0.05
5.1	3.2	4.4	2.0	21	0.2	0.06
5.7	3.8	5.3	2.3	23	0.2	0.37
6.1	4.0	5.5	2.4	24	0.2	0.47
6.3	4.4	5.8	2.5	25	0.2	0.61
6.6	4.6	6.1	3.2	26	0.2	0.78
6.9	4.8	6.4	3.3	27	0.3	0.96
7.3	5.1	6.7	3.4	28	0.4	1.18
7.4	5.2	7.1	3.5	29	0.5	1.35
7.8	5.5	7.4	3.4	30	0.3	1.60
8.0	5.7	7.5	3.5	31	0.3	1.72
8.3	6.0	7.9	3.6	32	0.3	1.99
8.5	6.2	8.2	3.4	33	0.3	2.80
8.8	6.5	8.5	4.0	34	0.3	2.42
8.9	6.7	8.7	4.0	35	0.5	2.56
9.1	6.8	8.9	4.6	36	0.5	2.72
9.4	7.0	9.3	4.1	37	0.3	3.05
9.5	7.2	9.7	4.2	38	0.7	0.22
9.5	7.3	9.9	4.2	39	0.5	3.27
9.8	7.4	10.0	4.2	40	0.2	3.52

Table 3: Correlation between Foetal Renal Length and Other Biometric parameters.

Biometric Parameters	Person's Correlation Coefficient (r)	P-Value
Biparietal Diameter (BPD)	0.966	0.000
Femur length (FL)	0.965	0.000
Transverse Abdominal diameter (TAD)	0.960	0.000

Discussion

It is very important and helpful to sonographically know the normal ranges of foetal kidney lengths (cm) in-utero in relation to gestational age (weeks) in order to establishing a nomogram of prenatal foetal kidney length in normal pregnancies in a Nigerian population. This is imperative as biaparietal diameter, femoral length, transabdominal diameter and other biometric parameters have been giving lower or higher values in second and third trimesters of gestation.

This study is aimed at establishing sonographically a nomogram of mean fetal kidney length (FKL) in normal Nigerian fetuses, for use in conjunction or as complimentary to other biometric paramerts in determing gestational ages (in weeks) during second and third trimesters. The observed values of foetal kidney length in this study were compared with those of Caucasian values to ascertain if there are any relationships with regard to racial differences.

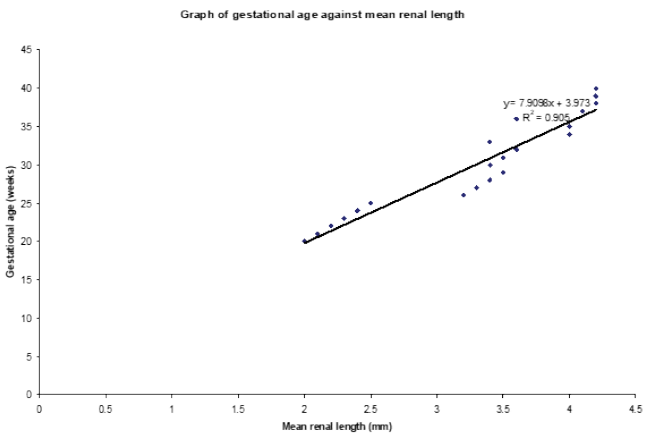

Figure 2: Graph of gestational age against foetal renal length in the study group.

In this study, lengths of prenatal foetal kidneys were measured in 247 normal singleton pregnant women. The total mean foetal kidney length obtained is 70.2cm ±7.19SD (table 1). Measurements of kidney length at various gestational ages during pregnancy were obtained. At 20weeks renal length was 2.0cm, 21weeks it was 2.1cm and at 22 weeks it was 2.2cm (table 1). It exhibited linearity trend with the gestational age with little deviation at 30weeks, 33 weeks and 36weeks where their values are 3.4cm, 3.4cm and 3.6cm respectively.

Substituting the linearity equation Y(GA) = 7.9098(RL) + 3.973. The result of this study showed that at renal length of 2.0cm, GA = 19.8weeks ±0.2SD, at 3.4cm, GA = 30.9weeks ±0.3SD, at 4.4cm, GA = 38.8weeks ±0.5SD. In figure 2 (graph of gestational age against mean renal length), strong linear relationship was found between the observed renal length and the predicted values of the dependent variable gestational age ($r= 0.954$, $p < 0.05$).

This implies that foetal renal length can be used to predict gestational age. Foetal kidney length increases with time. Growth rate was 0.1cm from 20weeks to 24weeks gestation and 0.12cm from 25weeks to 28weeks. The growth rate declined to 0.1cm at the third trimester (30weeks to 40weeks). The fastest foetal renal growth rate was recorded from 25weeks to 28weeks gestational ages.

From this study foetal renal length can also be used as a parameter or in combination of other biometric parameters for estimating the gestational age of the foetus. At femoral length of 74cm and above fetal gestational age was postdating. Similarly, at transabdominal diameter of 10.0cm, gestational age was also postdated. These discrepancies in relation to femoral length and TAD will clinically lead to induced labor or caesarian section in some cases. Therefore, at this stage of gestation, fetal renal length becomes the most accurate alternative to ascertain the actual GA. This is easier because as the pregnancy progresses, increased echogenicity from increasing perinephric fat is said to make them more visible by allowing easier separation of the kidney from its soft tissue surrounding [9].

Therefore, establishing normal prenatal kidney length is helpful in eliminating these errors. The result of the present study shows that renal lengths in Nigerian foetuses at different gestational ages exhibited linearity trend. Similar trend is noted in the Caucasians. This indicates that the growth patterns of foetal kidneys in the two races were similar. The normal values of mean renal length established in the present study were significantly different from the Caucasian values ($p<0.05$). The values were consistently smaller compared with earlier Caucasian values reported by Jeanty et al, (1982) and Bertagnoli et al, [10]. Measurements at several points of pregnancy by Harris et al, [8] are compared with our measurements. At 20, 21 and 22 weeks, mean renal lengths in our established local nomogram are 2.0cm, 2.1cm and 2.2cm respectively. While in Caucasian the nomogram of mean kidney lengths is 2.6cm, 2.7cm and 2.7cm respectively for corresponding gestational. These results show that their values are higher than ours. These racial differences may be attributed to genetic, nutritional and environmental factors. However, their values of 4.2cm to 4.5cm at term were similar to our values at term.

Also, Kurtz and Goldberg [9] in their review of studies of obstetric measurements noted only two earlier studies of foetal kidney length that used real-time equipment. Both of those studies showed values greater than those of the present study.

In relation to expected fetal birth weight, Erwin et al, [11] found mean neonatal renal lengths to be 4.2cm, for neonates weighing more than 3.5kg. For those weighing between 3.0kg and 3.5kg the mean renal length was 4.0cm.

Expected fetal weights of our foetuses with mean renal lengths of 4.2cm is 3.52kg. This is similar to Caucasian values [12]. These values are also similar to those of our foetuses at term [13].

Therefore, this study found statistically significant difference between mean renal length of the study population in early stage of in-utero life to that of the Caucasians. The values are fairly similar at term for both races [14].

Conclusion:

This study showed that gestational age is fairly linearly related to renal length. The measurement is easy to make and could therefore be easily incorporated into the model for dating pregnancies using the equation.

Y (GA) = 7.9098 (RL) + 3.973.

The period from 25weeks to 28weeks gestation is the fastest of in-utero foetal kidney growth rate. However, this does not imply that it is the most suitable period for dating gestational age using foetal kidney length.

Foetal kidney length can be used singly or in combination with other biometric parameters in gestational age estimation during second and third trimester. Our mean renal lengths were shorter than those of earlier reports in Caucasians but are fairly consistent with some later studies and neonatal measurements in other published studies. The study has shown that racial difference exists in foetal kidney lengths in early in-utero life.

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