Original Article

Sonographic estimation of gestational age using transverse cerebellar diameter among late trimester pregnancies in Kano, Northwest Nigeria

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Abstract

Background/Context: Accurate estimation of fetal gestational age (GA) is of paramount importance in the management of all pregnancies, especially for the planning of mode of the delivery and management of high-risk pregnancies. Obstetric ultrasonography is a simple, available, affordable, and noninvasive modality for estimating fetal GA due to its high safety profile. The fetal cerebellum is easily visualized and reliably identified on ultrasound in the posterior cranial fossa after 14 weeks of gestation.

Aim: The aim of this study was to evaluate the utility of transverse cerebellar diameter (TCD) in determining GA in second- and third-trimester pregnancies and compare its accuracy with other established sonographically derived fetal biometric parameters.

Materials and Methods: A total of 424 pregnant women in their second and third trimesters who were sure of their last menstrual period (LMP) were recruited into the study over a period of 6 months (May to November 2019) at the Radiology Department of AKTH-Kano, Nigeria. The corresponding fetal TCD and other established fetal biometric indices (biparietal diameter [BPD], head circumference [HC], abdominal circumference [AC], and femur length [FL]) were sonographically obtained and correlated. Pearson's bivariate coefficient was used to establish the correlation between the traditional biometric indices with TCD and GA derived by LMP. Multivariate linear regression analysis was used to assess the accuracy of the studied indices in predicting GA.

Results: The range for TCD in second- and third-trimester fetuses was 15.9–57.5 mm. The TCD parameter was more accurate (±1.753 days) than BPD (±2.298 days), HC (±2.337 days), and AC (±4.342 days) and marginally less accurate than FL (±1.165 days) in predicting GA among study subjects ($P < 0.001$).

Conclusion: TCD is a reliable and accurate parameter for GA estimation in late second- and third-trimester pregnancies when compared with established fetal biometric parameters among pregnant women in Kano, Nigeria.

Keywords: Estimation and third trimester, gestational age, transcerebellar diameter, ultrasound

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INTRODUCTION

The American College of Obstetricians and Gynecologists defined gestational age (GA) as the duration of pregnancy after the 1st day of the last menstrual period (LMP) before conception.[1,2] The cerebellum is the part of the fetal brain that lies in the posterior cranial fossa, posterior to the pons and medulla with the 4th ventricle separating them.[3,4] The cerebellum plays a very important role in the coordination of fine motor movements, muscle tone, balance, and equilibrium in the human body.[5]

The two widely used and accepted methods of estimating fetal maturity are GA and estimated fetal weights.[6] Accurate and reliable knowledge of GA plays a crucial role in the management of all pregnancies, specifically for antepartum planning of delivery modes, management of high-risk pregnancies, and elective planning of induction of labor or cesarean section among patients with a history of previous operative deliveries.[6,7]

The three basic methods used in the estimation of GA are menstrual history, clinical examination, and ultrasonography. The first two methods are subject to considerable error and should only be used when ultrasonography facilities are not available.[1] The considerably higher reliability and accuracy of ultrasonography in the assessment of GA makes it a valuable tool in obstetric care. Additional benefits of being a noninvasive, affordable, and free of ionizing radiation risks modality make ultrasound very safe for both mother and developing fetus during pregnancy.[6] Ultrasonography is routinely used to assess and estimate GA by measuring established parameters such as gestational sac diameter and crown-rump length in the first trimester, the biparietal diameter (BPD), femur length (FL), head circumference (HC), and abdominal circumference (AC) in second and third trimesters.[8] In addition, orbital diameters, binocular distance, fetal thoracic circumference, embryonic trunk circumference, fetal heel ossification, and foot length measurements have also been reported to be used for GA assessment to a lesser extent.[7-9] However, the significant variability noticed in the assessment of GA with these established parameters is amplified with increasing GA.[10]

Since the last decade, TCD has gained increasing acceptance due to its considerably high accuracy in predicting GA among third-trimester fetuses with unreliable LMPs and also due to the minimal effects of intrauterine growth restriction on the fetal cerebellum, unlike other parameters that are sensitive to fetal growth disturbances.[11] Furthermore, it has been observed that during the third trimester, when there is excessive molding of the fetal head, BPD and HC may become quite unreliable. Therefore, TCD becomes a more suitable and reliable measure for the estimation of GA since the cerebellum is not liable to change in its form and size due to protection by dense petrous and occipital bones.[11]

Fetal cerebellar diameter in normal gestation and restricted fetuses have been found to correlate with fetal growth indices, such as BPD, HC, and AC among southern Nigerian population.[11] It has been reported that TCD correlates excellently with GA as well as predicts menstrual age within 5 days in 98.7% of second- and third-trimester pregnancies.[12,13] TCD was reported as showing 92% predictive accuracy for GA compared to the conventional nomogram of FL and BPD among Indian and Nepalese Populations.[13-15]

There is a paucity of data about the sonographic estimation of GA using TCD among northern Nigerian population. In addition, northern Nigeria has a large number of pregnant women who do not reliably know their LMP and the low level of first-trimester ultrasound scan practice among pregnant women in this environment.[16]

This present study aims to compare the predictive accuracy of fetal transverse cerebellar diameter (TCD) in the estimation of LMP-derived GA among second- and third-trimester singleton pregnancies in comparison to sonographically established fetal biometric parameters in the estimation of GA in Kano, Nigeria.

MATERIALS AND METHODS

Four hundred and twenty-four normal singleton pregnant subjects between 15 and 40 weeks of GA who consented to participate in this study following IRB approval were recruited from the Antenatal Clinic of O and G Department of our hospital. Systematic random sampling method with sequential enlistments was used while Fisher's formula for descriptive studies was used to determine the sample size.[17] Apparently, healthy pregnant women between the ages of 19 and 45 years in the second and third trimesters who satisfied the inclusion criteria were included in the study. Nineteen were in the second trimester and 243 were in the third trimester of their pregnancies, respectively. Subjects with index pregnancy history of maternal hypertension, gestational diabetes, antepartum or postpartum hemorrhages, or multiple gestation were excluded from the study. After obtaining sociodemographic characteristics, all subjects were scanned using a real-time B-mode ultrasound scanner (Nortek S-50, Shenzhen, China, 2015) using a 3.5 MHz curvilinear transducer.

Scanning was done in supine or right/left lateral oblique positions (through the flanks) for patients with advanced third-trimester pregnancy having abdominal compression symptoms by the gravid uterus, after which the following parameters were obtained for each study subject:

- BPD was imaged in the transaxial plane of the fetal head at a level depicting the thalamus in the midline with BPD measured from the outer edge of the cranium nearest the transducer to the inner edge of the cranium farthest from the transducer[18]
- HC measurement was obtained at the same level described for BPD and measurement was done by tracing along the outer edge of the cranium using the ellipse feature[18]
- AC was obtained in the transaxial plane of the fetal abdomen and AC was measured at the level of the fetal liver with measurements taken from the outermost aspects of the fetal soft tissue[18]
- FL was obtained by aligning the transducer to the long axis of the femoral diaphysis and measurements taken from the greater trochanter to the lateral condyle[18]
- Transverse cerebellar diameter (TCD) was obtained in the axial transcerebellar plane with the landmarks of thalami, cavum septum pellucidum, and third ventricle, following the appearance of the butterfly-shaped cerebellum in the posterior cranial fossa. TCD was measured from the outer to outer echogenic margins of the cerebellar hemispheres [Figure 1].[18]

All parameters (BPD, HC, AC, FL, and TCD) were obtained and recorded in millimeters (mm) and were automatically computed by the ultrasound machine using Hadlock tables with pregnancy duration obtained in weeks.

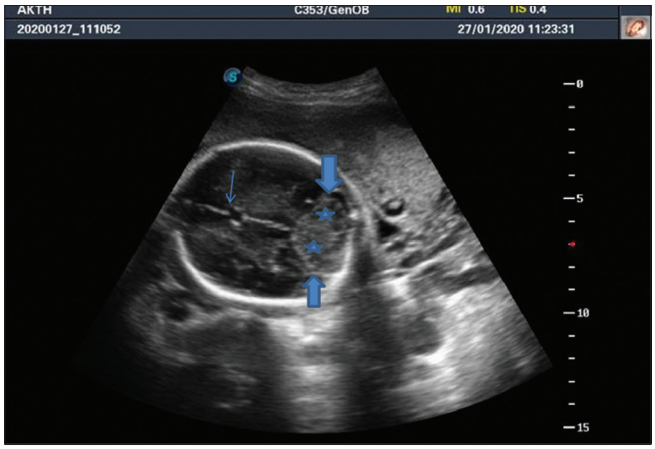

Figure 1: Sonographic axial image of the fetal head depicting plane for measurement of transverse cerebellar diameter. The thalami, cavum septum pellucidum (thin blue arrow), and third ventricle were identified, with the posterior fossa showing the characteristic butterfly-like appearance of the cerebellum (*). The TCD is measured from the outer margins of the cerebellum (as shown by thick blue arrows)

Statistical analysis was done using Statistical Products and Service Solution (IBM SPSS) Version 23.0 (IBM Corp., Armonk, NY, USA). with $P \leq 0.05$. The mean ± standard deviation for patients' demographics and fetal biometric parameters were obtained and analyzed for descriptive statistics. Regression analysis was done to compare each sonographically measured parameter (TCD, BPD, HC, AC, and FL) with LMP-derived GA of the fetus, and Pearson's correlation coefficients were then used to compare TCD with GA, BPD, HC, AC, and FL among subjects. Data obtained were also utilized to establish nomograms by taking the 5th, 50th, and 95th percentile values.

RESULTS

Four hundred and twenty-four normal singleton pregnant subjects between 15 and 40 weeks of GA were evaluated. The maternal age ranged from 19 to 48 years with the 29–33 age group having the highest frequency of 37.2% and the age group of 44–48 years being the least frequent accounting for only 2.3% of the study subjects, as shown in Figure 2.

The majority (31.5%) of subjects were third-trimester GA between 30 and 34 weeks, followed by those between 35 and 40 weeks with a frequency of 24.2%. The least group being those of 15–19 weeks of GA, as shown in Figure 3.

Study subject's parity consisted of primigravida, primipara, multipara, and grand multiparous women with the largest proportion being multiparous (49%) with the least percentage coming from primigravid women (15%) as in Figure 4.

The mean transverse cerebellar diameter (TCD) showed a steady increase from 16.5 mm ± 0.77 at 15 weeks of gestation and peaked at 55.6 mm ± 0.22 at 40 weeks of gestation.

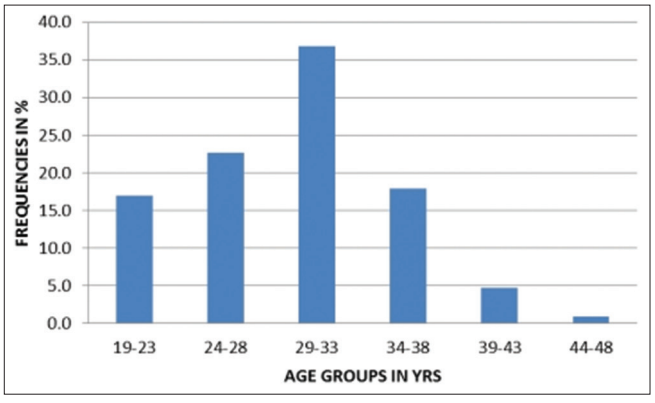

Figure 2: The bar chart showing the age distribution among the patients studied

The sonographically derived data normogram of TCD for normal pregnancy at specific GAs was derived with the mean TCD in millimeters as well as the 5th and 95th percentiles for the corresponding GA, as shown in Table 1.

There was a significant linear and strong positive correlation (r = 0.964) between TCD and GA by LMP (P < 0.001), as shown in Figure 5. The significant correlation was comparatively less strong between LMP-derived GA and other measured traditional fetal biometric indices such as BPD, HC, and AC except for FL (r = 0.984) which was stronger than TCD. The correlation values were BPD (r = 0.880) and HC (r = 0.875), while the least correlation was exhibited between GA and AC (r = 0.755). Furthermore, there was a significant linear-positive correlation between TCD with traditional fetal parameters such as BPD, HC, AC, and FL (P = 0.000) with the strongest correlation observed between TCD and FL (r = 0.957) and the least correlation was between TCD and AC (r = 0.748).

Linear regression analysis to assess the accuracy of the individual fetal biometric indices in predicting GA between 15 and 40 weeks of gestation revealed a good accuracy for TCD just after FL and the least accurate at predicting GA was AC, as shown in Table 2.

Table 1: Predicted transverse cerebellar diameter measurement values at specific menstrual gestational ages (i.e., transverse cerebellar diameter normogram)

GA (weeks)	Mean TCD (mm)	95% CI		Frequency, *n* (%)
		Lower bound	Upper bound	
15	16.5	15.9	17.1	8 (1.9)
16	17.9	17.4	18.3	9 (2.1)
17	18.1	17.7	18.6	13 (3.1)
18	18.7	17.8	19.6	8 (1.9)
19	19.9	18.3	21.6	8 (1.9)
20	21.2	20.5	21.9	13 (3.1)
21	23.1	22.4	23.8	28 (6.6)
22	24.2	23.5	25.1	16 (3.8)
23	25.7	24.6	26.8	16 (3.8)
24	27.5	26.5	28.5	4 (0.9)
25	29.1	27.1	31.1	11 (2.6)
26	30.4	29.7	31.1	28 (6.6)
27	33.1	32.2	34.1	16 (3.8)
28	33.7	32.3	35.0	12 (2.8)
29	38.5	35.4	41.5	4 (0.9)
30	40.5	39.3	41.6	48 (11.3)
31	42.3	40.4	44.1	20 (4.7)
32	43.6	42.6	44.9	16 (3.8)
33	44.3	42.3	46.2	4 (0.9)
34	4.66	4.55	4.78	43 (10.1)
35	4.6	4.11	5.08	12 (2.8)
36	5.16	5.03	5.29	29 (6.8)
37	5.28	5.1	5.46	18 (4.2)
38	5.24	5.04	5.44	21 (5.0)
39	5.52	5.48	5.56	10 (2.4)
40	5.57	5.39	5.75	9 (2.1)

TCD – Transverse cerebellar diameter, CI – Confidence interval, GA – Gestational age

DISCUSSION

Accurate dating of pregnancies is of vital importance and plays a key role in the planning of deliveries, especially

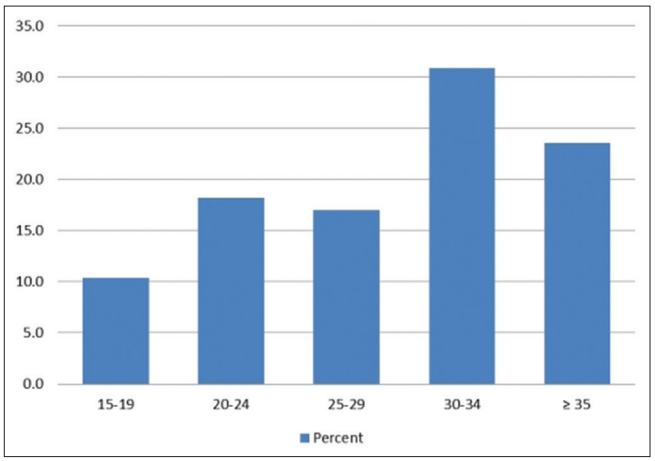

Figure 3: The bar chart showing the gestational ages of the pregnant women recruited for the study

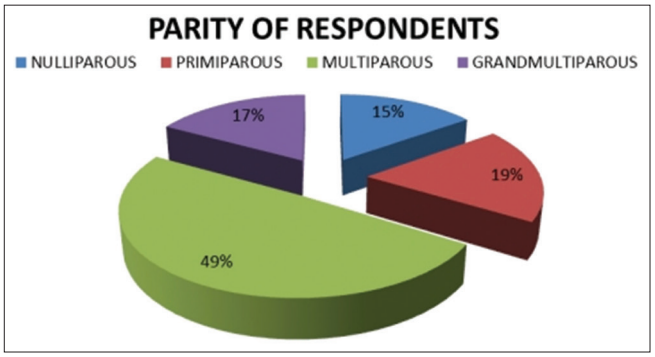

Figure 4: The pie chart showing the parity distribution among the patient's population

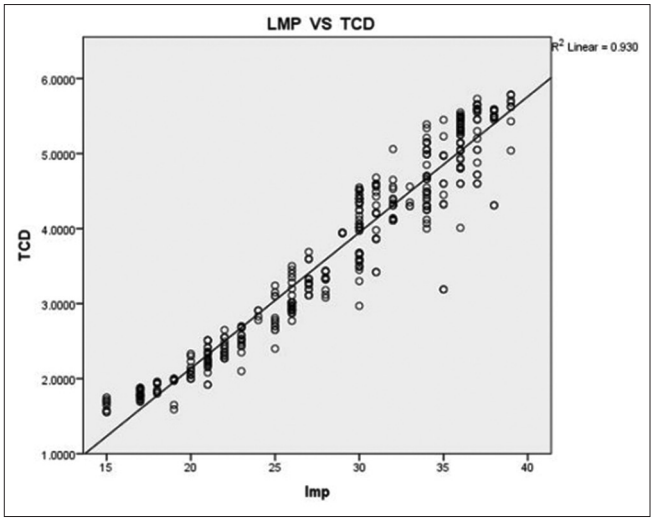

Figure 5: Scatter plot graph showing the relationship between TCD and gestational age by last menstrual period. LMP – Last menstrual period, GA – Gestational age

Table 2: Standard error of prediction of transverse cerebellar diameter and other traditional fetal biometric indices

Parameter	*P*	R^2	SEpred (days)
FL	<0.01	0.969	1.165
TCD	<0.01	0.930	1.753
BPD	<0.01	0.880	2.298
HC	<0.01	0.875	2.337
AC	<0.01	0.570	4.342

Dependent variable: LMP. SEpred – Standard error of prediction (days), LMP – Last menstrual period, FL – Femur length, TCD – Transverse cerebellar diameter, BPD – Biparietal diameter, HC – Head circumference, AC – Abdominal circumference

for those with fetuses who have growth disturbances or other maternal indications for medical interventions during pregnancy. Among the various clinical criteria, LMP preceded by normal cycle is known to best correlate with the GA but becomes unreliable when a woman is unsure of her LMP. Ultrasonography is routinely used for dating of pregnancy. The traditional fetal biometric parameters used for GA estimations include BPD, HC, AC, and FL.[8] However, each of these parameters has its own limitations.[10] TCD is a unique parameter for estimating the GA of fetuses. In this study of 424 subjects with known LMP recruited for this study, the age range was 19–45 years with a mean of 29.6 ± 5.5 years. This is comparable to the age of subjects recruited in the study of Adeyekun and Orji[11] in Benin City, southern Nigeria. In the work by Pavithra *et al*.[19] and Agrawal *et al*.,[20] both in India, the age range of their subjects was 18–35 years with a mean of 23.5 years and 24.82 ± 3.31 years, respectively, which were both lower than that of the index study. This could be due to the much earlier age of marriage among South Indian population when compared to Nigeria.

The GAs of the pregnancies in the index study ranged from 15 to 40 weeks with the majority of patients in their third trimester (30–34 weeks). This agrees with the study of Eze *et al*.[6] conducted in Enugu, Nigeria, and Sumanta *et al*.[21] in India and Mahmoud *et al*.[22] in Sudan. The study of Adeyekun and Orji[11] in Benin, Nigeria, despite having the studied population in their 2nd and 3rd trimesters, showed the majority of subjects to be <30 weeks of GA. This may be because women in the Southern part of Nigeria have better health-seeking behaviors than those in the Northern part of Nigeria thereby seeking for medical care at an earlier stage of their pregnancy than women in Northern Nigeria.[23]

In the present study, sonographic visualization of the cerebellum occurred at 15 weeks of GA, which was earlier at 12–13 weeks of GA in a similar study by Goel *et al*.[13] in India despite their smaller sample size of 50. These differences could probably be due to racial/genetic differences between the two populations. However, in another study by Naseem *et al*.[24] in Pakistan, visualization of the cerebellum occurred much later at about 17 weeks of GA. This could be due to the use of different models of ultrasound machines and possible differences in the level of expertise between both investigators.

The TCD showed a linear increase with advancing LMP-derived GA with a significantly strong positive correlation. This was similar to the findings of Eze *et al*.[6] in southern Nigeria which also showed a strong positive correlation between TCD and GA. This could have been due to similar GAs of subjects in both studies. Moreover, Nagesh *et al*.[25] in India observed a similar linear relationship between TCD and fetal GA between 15 and 40 weeks of gestation with a significant positive correlation ($r = 0.992$, $P < 0.001$).

In our study, we observed a significantly strong positive correlation between the TCD and the other traditional fetal biometric indices (i.e., BPD, HC, AC, and FL) with the linear relationship between TCD and FL being strongest among the biometric parameters studied. In comparison with the study of Sumanta *et al*.[21] in India, where the GA estimated by TCD correlated linearly with the BDP and FL-derived estimated GA. Furthermore, Ravindernath *et al*.[18] in South India showed a good correlation between TCD and other fetal biometric parameters. The similarity could be attributed to similarities in LMP-derived GA of the two study groups.

However, in contrast to the present study, the highest correlation was observed between TCD and HC in the study Pavithra *et al*.[19]

In addition, Naseem *et al*.[24] in Pakistan studied 228 singleton pregnancies and found TCD to give an accurate assessment in 209 patients (91.7%; $P = 0.001$), precisely corresponding to GA by LMP at 36 weeks. BPD was found to also exactly correspond to LMP-derived GA in 176 patients (77.2%) at 36 weeks. Although both BPD and TCD accurately predicted GA at 36 weeks, TCD was comparatively a more reliable parameter than BPD in the third trimester of pregnancy. These findings are similar to what was obtained in our study despite the difference in sample size.

This study was limited by the disproportionately large number of third-trimester pregnancies thus making comparison of accuracy of TCD between second and

third trimesters difficult. Furthermore, the cross-sectional design of the study may have underestimated the accuracy of TCD as comparison could not be longitudinally made with the actual delivery date of individual patients due to the absence of follow-up.

CONCLUSION

Transcerebellar diameter showed a linear increase with GA and is strongly correlated with LMP-derived GA as well as other traditional fetal biometric parameters. If transcerebellar diameter is measured accurately in the correct imaging plane, it can be used reliably as an additional parameter to predict GA in the third trimester of pregnancy in conjunction with other established parameters or when other methods fail to contribute to the assessment of GA during pregnancy.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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