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PREDICTIVE ACCURACY OF TRANSCEREBELLAR DIAMETER IN COMPARISON WITH OTHER FOETAL B IOMETRIC PARAMETERS FOR GESTATIONAL AGE ESTIMATION AMONG PREGNANT NIGERIAN WOMEN
A. A. Adeyekun, MCBhB, FWACS and M.O. Orji, MBBS, FWACS, Department of Radiology, University of Benin Teaching Hospital, PMB 1111, Benin City, Nigeria.

PREDICTIVE ACCURACY OF TRANSCEREBELLAR DIAMETER IN COMPARISON WITH OTHER FOETAL BIOMETRIC PARAMETERS FOR GESTATIONAL AGE ESTIMATION AMONG PREGNANT NIGERIAN WOMEN

A. A. ADEYEKUN and M. O. ORJI

ABSTRACT

***Objective*: To compare the predictive accuracy of foetal trans-cerebellar diameter(TCD) with those of other biometric parameters in the estimation of gestational age (GA).**
***Design*: A cross-sectional study.**
***Setting*: The University of Benin Teaching Hospital, Nigeria.**
***Subjects*: Four hundred and fifty healthy singleton pregnant women, between 14-42 weeks gestation.**
***Main Outcome measures*: trans-cerebellar diameter (TCD), biparietal diameter (BPD), femur length (FL), abdominal circumference (AC) values across the gestational age range studied. Correlation and predictive values of TCD compared to those of other biometric parameters.**
***Results*: The range of values for TCD was 11.9 -59.7mm (mean =34.2±14.1mm). TCD correlated more significantly with menstrual age compared with other biometric parameters (r=0.984, p=0.000). TCD had a higher predictive accuracy of 96.9%±12 days), BPD (93.8%±14.1days). AC (92.7% ± 15.3days).**
***Conclusion*: TCD has a stronger predictive accuracy for gestational age compared to other routinely used foetal biometric parameters among Nigerian Africans.**

INTRODUCTION

Foetal growth is dynamic, thus no single biometric parameter is completely accurate or reliable throughout gestation. The following foetal biometric parameters such as gestational sac diameter, crown-rump length, head circumference, BPD, FL, and AC, among others, are routinely assessed, for estimation of GA (1).

The gestational sac can be visualised at four weeks and four days' menstrual age (average sac diameter 3.0mm), using transvaginal ultrasonography. (2) The overall accuracy of gestational sac diameter in estimating embryonic age is to the nearest one week (3).

The crown-rump length has generally been considered the most accurate method of assessing GA between the 7th and 11th week of intrauterine life. (4) However, its accuracy decreases beyond this period due to increased curvature of the foetus, which affects reliability of measurement.

The BPD when used between 15 and 25 weeks menstrual age is comparable to the CRL in determining gestational age (5). Its reliability decreases with advancing menstrual age. (5,6) Abnormalities of foetal head shape such as dolicocephaly, brachycephaly or foetal skull moulding at term may affect the use of BPD in estimating GA (7).

Measurement of the HC has become an integral part of assessing menstrual age in the second and third trimesters. It is more reliable between 13 and 25 weeks, and the observed variability with in its use in estimating GA is generally less than that with BPD (6).

FL was originally measured to detect short-limbed dysplasias. (8) The reported inter-observer variation in the measurement of FL is 4.4mm. (9) FL measurement is more reliable between 13 and 25 weeks gestation. Some studies rated FL over BPD in assessing menstrual age, while others found the two parameters comparable (10).

The TCD is measured as the widest diameter across both foetal cerebellar hemispheres in an outer-to-outer fashion. It has been found by some authors to correlate excellently with GA as well as predict menstrual age within five days in 98.7% of second and third trimester pregnancies (11). TCD was reported as showing 92% predictive accuracy for gestational age compared to the standard normogram of FL and BPD (12).

TCD is not affected by foetal skull shape,

and between 14 to 20 weeks gestation, the TCD in millimetres is roughly equivalent to the menstrual age in weeks (5,10). In fetal conditions like dolicocephaly or brachycephaly TCD may be a more reliable predictor of GA than BPD, since the posterior fossa is not usually affected by factors that may induce foetal head distortion. Since TCD seems relatively unaffected by intrauterine growth restriction (IUGR), measuring TCD is especially advantageous when IUGR is suspected or when GA is uncertain (13,14).

There is paucity of data on the relative applicability of TCD compared to other foetal biometric parameters in estimating GA among Nigerian Africans. This study was therefore undertaken to correlate TCD with GA and determine its predictive accuracy when compared to other foetal biometric parameters.

MATERIALS AND METHODS

A total of 450 healthy singleton pregnancies were examined sonographically at the University of Benin Teaching Hospital, Benin City, Nigeria over a seven month period, following informed consent. The inclusion criteria were certain last menstrual dates and gestational age (by last period) between 13 and 42 weeks. Women with hypertension (pregnancy induced, essential), sickle cell hemoglobinopathy, diabetes mellitus, were excluded. Also foetuses with congenital anomalies were excluded. The approval of the hospital's Ethics and Research Committee was obtained.

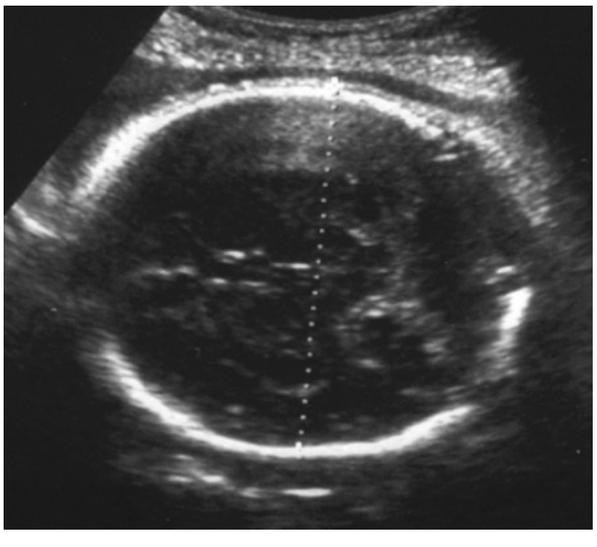
Sonograms were obtained with the 3.5MHz curvilinear probe of a Sonoace X6 machine (Medison Inc, Korea 2010). The following parameters were measured TCD, BPD, AC, and FL using the appropriate planes as described below. For each parameter, three measurements were obtained and the average value recorded as final.

TCD: Using the horizontal plane of the foetal head, the landmark of the thalami and cavum septum pellucidum were identified in the midline. The transducer was slightly rotated caudally to bring the characteristic "butterfly" appearance of the cerebellum into view, as proposed by Meyer et al. (15) TCD was then measured as the widest diameter across both hemispheres in outer-to-outer fashion (Figure 1).

Figure 1
Transverse cerebellar diameter measurement on horizontal ultrasound scan of the foetal head. The cursors are placed at the cerebellar margins

BPD: The axial plane through the widest portion of the fetal skull, where the continuous midline echo of falx cerebri is broken by the cavum septum pellucidum, with both thalami enclosing the 3rd ventricle was used. (9); Figure 2.

Figure 2
Sonogram showing the fetal head at the plane of measurement for biparietal diameter



AC: The abdominal circumference was taken at the level where the umbilical vein enters the left branch of the portal vein, with the stomach and spine also

included in view. (16) The abdominal outline was as circular as possible. (1) Tracing was done by the elliptical method (Figure 3).

Figure 3
Sonogram of transverse section of the fetal abdomen for measurement of the abdominal circumference

FL: The femur length was measured along the long axis of the diaphysis, starting from the proximal hyperechoic hook to the distal portion of the lateral condyle below. (1,11) The ultrasound beam was oriented perpendicular to the long axis of the femur for optimal measurement (Figure 4).

Figure 4
Sonogram showing the long axis of the thigh for measurement of femur length

All the measurements were analysed using the Statistical Package for the Social Sciences (SPSS) Windows Version 16.0 (Chicago IL). Frequency and contingency tables, graphs and charts were used to present results. Statistical tests of significance were done with ANOVA (Analysis of Variance) for proportions of means and Pearson's correlation for discrete and continuous variables. At 95% confidence interval, probability values less than or equal to 0.05 were considered significant.

RESULTS

Four hundred and fifty healthy singleton pregnancies were studied within the 13 – 42 weeks gestational age range. The mean age of the women was 30.1±4.4 years, with the modal age group of 26 – 30 years (37.6%). One hundred and seventy-five women (38.9%) were nulliparas.

Table 1 shows gestational ages of the scans done. The modal gestational age group was 33 – 37 weeks (111 women or 24.2%).

Table 2 shows the mean TCD values at gestational ages 13 – 42 weeks. The mean TCD at 13 weeks was 12.8±0.8mm, and at 42 weeks was 58.9±0.2mm. The overall mean TCD was 34.2±14.1mm.

Table 3 shows predicted normal ranges and centiles for TCD for each GA. There was significant correlation between TCD and menstrual gestational age ($r = 0.984$; $p = 0.000$). Also FL, BPD and AC showed good correlation with menstrual age $r = 0.974$, 0.969 and 0.963 respectively. TCD correlated with GA better than the other three parameters. 'p' values for FL, BPD and AC at 95% confidence interval was 0.000. This is as shown in Table 4.

Linear regression models for estimation of gestational age were derived from all the biometric indices (TCD, BPD, FL and AC). In addition, stepwise regression models were constructed to determine the best model for determination of gestational age between 13 to 42 weeks gestation. Comparison of the accuracy of these models in determination of gestational age showed that TCD has 96.9% predictive accuracy, with a standard error of 10.1 days. This was followed by FL (94.9% ± 12.8 days); BPD (93.8% ± 14.1 days) and AC (92.7% ± 15.3 days).

A linear regression model including TCD, FL and BPD and another model comprising TCD and FL each showed 97.9% predictive accuracy, while a model having TCD and BPD showed 97.8% predictive accuracy. These models with TCD were more accurate than models derived from the 'standard' biometric indices (FL, BPD and AC), which showed 95.3% ± 12.3 days predictive accuracy. Thus from the linear regression TCD was found to be the most accurate single parameter for predicting GA, followed by FL, with AC being the least accurate (Figure 5).

Table 1
Distribution of number of scans according to gestational age

Gestational age group (weeks)	Frequency	Percentage	Cumulative Percentage
13 – 17	65	14.4	14.4
18 – 22	78	17.3	31.8
23 – 27	81	18.0	49.8
28 – 32	67	14.9	64.7
33 – 37	111	24.7	89.3
38 – 42	48	10.7	100.0

Table 2
Mean trans-cerebellar diameter at specific gestational age

Menstrual Gestational age (weeks)	TCD (mm) Mean ± SD	Frequency (N)	Percentage	Cumulative Percent
13	12.85 ± 0.8	11	2.4	2.4
14	13.63 ± 1.0	14	3.2	5.6
15	14.93 ± 0.8	11	2.4	8.0
16	15.63 ± 0.7	18	4.0	12.0
17	16.55 ± 1.0	11	2.4	14.4
18	18.25 ± 0.8	15	3.3	17.8
19	19.50 ± 0.8	7	1.6	19.3
20	20.73 ± 0.6	15	3.3	22.7
21	21.58 ± 0.9	20	4.4	27.1
22	23.24 ± 2.0	21	4.7	31.8
23	24.32 ± 1.9	16	3.6	35.3
24	26.79 ± 1.6	19	4.2	39.6
25	28.54 ± 1.9	18	4.0	43.6
26	30.52 ± 2.8	16	3.6	47.1
27	31.32 ± 1.5	12	2.7	49.8
28	33.95 ± 3.1	11	2.4	52.2
29	35.49 ± 2.7	15	3.3	55.6
30	38.14 ± 2.6	13	2.9	58.4
31	39.46 ± 1.8	12	2.7	61.1
32	39.91 ± 2.3	16	3.6	64.7
33	42.92 ± 1.9	9	2.0	66.7
34	44.39 ± 3.2	17	3.8	70.4
35	46.96 ± 2.2	25	5.6	76.0
36	49.87 ± 3.4	29	6.4	82.4
37	50.94 ± 3.3	31	6.9	89.3
38	53.36 ± 2.2	25	5.6	94.9
39	54.88 ± 2.6	6	1.3	96.2
40	58.00 ± 0.0	4	0.9	97.1
41	58.30 ± 0.5	10	2.2	99.3
42	58.93 ± 0.2	3	0.7	100.0
Total	34.19 ± 14.1	450	100.0	

Table 3

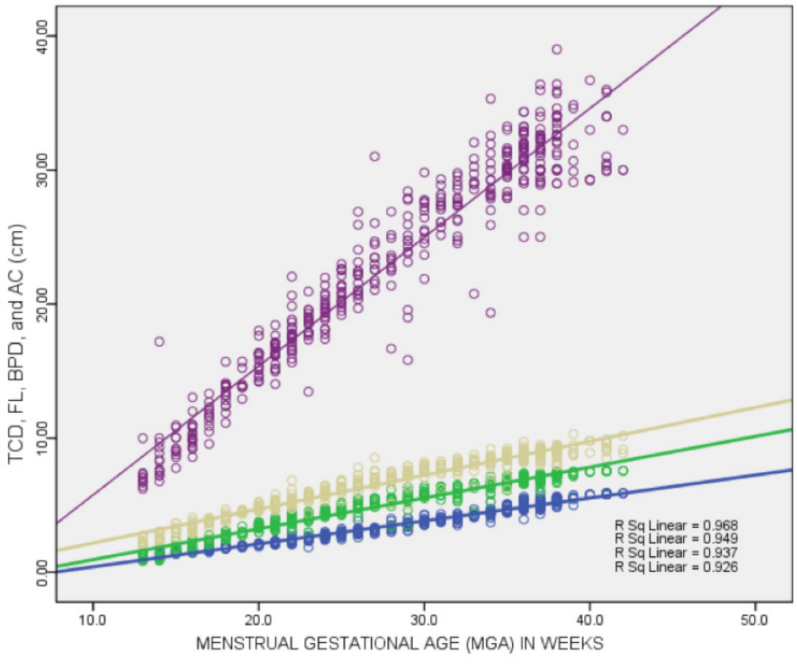
Predicted trans-cerebellar diameter (TCD) by gestational age (25th, 50th, 75th and 90th) percentile and the distribution of gestational ages of subjects included in the study (n = 450)

Menstrual Gestational	Percentiles					
Age	5	10	25	50	75	90
13	11.90	11.90	12.10	12.70	13.70	14.18
14	11.90	12.15	12.88	13.55	14.60	15.05
15	13.50	13.60	14.10	14.90	15.70	16.06
16	14.40	14.49	15.05	15.65	16.05	16.82
17	14.80	14.98	15.90	16.60	17.40	18.08
18	17.40	17.58	17.90	18.10	18.40	19.46
19	18.30	18.30	18.60	19.50	20.20	–
20	19.10	19.76	20.50	20.80	21.10	21.42
21	20.70	20.71	21.00	21.25	22.15	23.27
22	20.66	21.36	22.10	22.50	24.10	26.34
23	18.50	21.65	23.58	24.80	25.18	26.57
24	23.90	24.90	25.80	26.70	27.70	28.90
25	24.50	25.76	27.65	28.55	29.50	31.15
26	26.00	27.47	28.83	30.05	31.80	34.65
27	28.50	28.74	30.43	31.20	32.73	33.28
28	30.10	30.14	31.90	33.90	35.30	39.56
29	30.60	30.96	33.90	35.20	37.40	40.14
30	35.20	35.28	35.80	37.80	39.75	42.88
31	37.30	37.36	38.30	38.90	40.93	42.71
32	35.10	36.22	38.90	40.10	41.15	43.69
33	40.80	40.80	41.85	42.20	43.80	–
34	37.10	39.74	43.05	44.40	45.90	48.46
35	44.23	44.54	45.35	46.00	49.50	50.28
36	42.80	46.30	47.70	49.50	52.45	54.10
37	45.28	46.74	48.80	50.40	53.10	54.86
38	48.52	49.52	52.15	53.30	55.25	56.02
39	50.00	50.00	53.45	55.70	56.23	–
41	58.00	58.00	58.00	58.10	58.40	59.30
42	58.80	58.80	58.80	58.80	–	–

Table 4
Correlation of TCD, FL, BPD, AC with GA

		Menstrual Gestational Age	TCD IN Millimeter	Femur Length	Biparietal Diameter	Abdominal Circumference
Menstrual Gestational Age	PearsonCorrelation	1	.984**	.974**	.969**	.963**
TCD	PearsonCorrelation	.984**	1	.961**	.956**	.954**
FL	PearsonCorrelation	.974**	.961**	1	.984**	.978**
BPD	PearsonCorrelation	.969**	.956**	.984**	1	.974**
AC	PearsonCorrelation	.963**	.954**	.978**	.974**	1

Figure 5
Linear graph showing the correlation of menstrual gestational age (MGA) with TCD, FL, BPD and AC. Correlation coefficient, R2 of TCD is 0.968, FL is 0.949, while R2 of BPD is 0.937 and AC is 0.926. TCD appears to have a better and stronger correlation



● = Transverse Cerebellar Diameter (TCD)
● = Femur Length (FL)
● = Biparietal Diameter (BPD)
● = Abdominal Circumference (AC)

DISCUSSION

Accurate estimation of GA, especially when done in the first half of pregnancy is an important part of antenatal care. Obstetric ultrasound examination is very useful in achieving this. Routinely assessed parameters for GA estimation include FL, BPD, HC and AC. TCD is an emerging parameter previously found by some authors to be more accurate in predicting GA than the routine parameters (12, 17).

In this study, foetal biometric parameters were estimated at GA ranges between 23 – 27 weeks (81 women or 18%) and 33 – 37 weeks (111 women or 24.2%), with majority of the women, about 52.9% of the study population, presenting in the third trimester. This is due to late booking for antenatal care, which is characteristic of the Nigerian environment (18, 19).

The TCD values in this study ranged from 11.9 cm to 59.3 cm (mean: 34.2±14.1mm). The graph of mean TCD versus GA demonstrated a linear relationship with positive correlation in all trimesters ($r = 0.984$; $p < 0.000$). This agrees with the studies by Holanda Filho *et al* (20). and Pinar *et al* (21). However, Chavez *et al* (17) and Goldstein *et al* (22) noted linear relationship between TCD and GA for only first and second

trimesters, for which no specific reasons were given. This study found the TCD in millimetres to be roughly equivalent to menstrual gestational age between 14 to 20 weeks, as similarly reported previously (5, 10). The clinical significance of this is that it can serve as a quick way of assessing GA in women who cannot accurately remember their last menstrual period.

The present study observed that TCD has a better correlation and predictive accuracy (96.9% ± 5 days) than the more routinely used parameters, including FL (94.9% ± 13 days; BPD (93.8% ± 14 days); and AC (92.7% ± 15 days), as shown in Table 4. Similarly Chavez *et al* (17) reported a TCD predictive accuracy of 98.7% ± 5 days. Two models, one including TCD, FL and BPD and another comprising TCD and both showed increased predictive accuracy of 97.9%, with standard coefficients, β, of 0.613 for TCD, 0.290 for FL and 0.102 for BPD. Thus this study has shown that a composite model (TCD, FL and BPD) in normal foetuses may be better in predicting GA than any single parameter. Also TCD has been shown to be a more powerful and accurate predictor of GA than each of the routinely used parameters. The superiority of TCD over other parameters as found in this study tallies with previous reports (12,17, 22).

In conclusion, TCD has shown better correlation and predictive accuracy than other foetal biometrics in Nigerian Africans. It is therefore recommended that this parameter be incorporated into foetal biometry for GA assessment.

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