

Original Research Article

# Evaluation of Fetal Transcerebellar Diameter as a Sonological Parameter for the Estimation of Fetal Gestational Age in Comparison to Biparietal Diameter and Femur Length

Sumanta Kumar Mandal<sup>1</sup>, Sandip Kumar Ghosh<sup>2\*</sup>, Saikat Roy<sup>3</sup>, Barun Prakash<sup>4</sup>

<sup>1,2</sup>Associate Professor, <sup>3</sup>Radiologist, <sup>4</sup>Post Graduate Trainee, Bankura Sammilani Medical College, Bankura District, West Bengal, India

\*Corresponding author email: [ghsandipghosh@gmail.com](mailto:ghsandipghosh@gmail.com)

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## Abstract

**Background:** Knowledge of the expected date of delivery is essential in the management of all pregnancies, particularly those which require active management. Presently the most effective way to date the pregnancy is by the use of ultrasound. Several sonographically derived fetal parameters are used to date pregnancies, those include Biparietal diameter (BPD), Head circumference (HC), Abdominal circumference (AC) and femur length (FL). However, the variability of these parameters increases with increasing age. Transverse cerebellar diameter (TCD) measurement can be used as a new parameter to estimate the fetal gestational age. The present study was undertaken to evaluate the usefulness of Trans cerebellar diameter (TCD) as against other conventional parameters (like Biparietal diameter and Femur length) in normal pregnancies.

**Objectives:** To evaluate the usefulness of Trans cerebellar diameter (TCD) as against the conventional parameters of Biparietal diameter (BPD) and Femur length (FL) in normal pregnant mothers between 15-37 weeks, to derive nomogram for estimating the gestational age of the fetus from measured transverse cerebellar diameter.

**Materials and methods:** Study of 100 normal pregnant women between 15-37 weeks of gestation. For each patient BPD, FL and TCD were measured. From the above measured parameters gestational age was measured using Hadlock tables. TCD was compared with BPD, FL in normal pregnancies.

**Results:** It was observed that there was a statistically significant curvilinear relationship between TCD and gestational age in normal pregnancies. The growth pattern of cerebellum followed a second degree polynomial similar to that of BPD and FL. Gestational age estimated by TCD correlated well with the estimated gestational age by BPD and FL.

**Conclusion:** Transverse cerebellar diameter (TCD) shows good correlation with gestational age and can be used as a single growth parameter to estimate the gestational age where LMP is uncertain.

## Key words

Last menstrual period (LMP), Biparietal diameter (BPD), Femur length (FL), Transverse cerebellar diameter (TCD), Head circumference (HC), Abdominal circumference (AC).

## Introduction

Accurate knowledge of gestational age is very important in order to manage pregnancies especially regarding to cases like method of pregnancy termination, high risk pregnancies like pregnancy induced hypertension, diabetes, RH Incompatibility, etc. and planned labour induction [1].

Most commonly used method to estimate the gestational age is menstrual history [2], but it has several limitations such as: Many women do not recall the first day of last menstrual period, LMP may also be misleading due to oligomenorrhoea, abnormal bleeding events or use of oral contraceptives [3].

Due to these limitations ultrasonography is being widely used for the accurate assessment of gestational age using various parameters like biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) [4] and femur length (FL). However, these parameters shows increased variability with increasing gestational age due to factors like fetal skull moulding, deeply engaged head, hydrocephalus, microcephalus, etc. [5].

Due to these limitations of the conventionally used parameters, new parameters like Transcerebellar diameter (TCD) are being considered to be used for accurate assessment of

gestational age fetal growth retardation since it is minimally affected by the fetal growth and the changes associated with increasing gestational age [6, 7].

## Materials and methods

A prospective observational study was conducted among 100 women between 18 to 35 years with normal singleton pregnancies whose gestational age were confirmed by early ultrasound, over a study period of 7 months from October 2018 to April 2019. Consent was obtained from all study participants. Gestational ages from 15 to 37 weeks were included in the study. Ultrasound was performed on PHILIPS HD7 (2.0.1) using a 3-5 Mhz curvilinear transducer by two radiologists with ample experience. Radiologist one determined the average gestational age using hadlock's formula from fetal biometric indices like, abdominal circumference (AC), head circumference (HC), femur length (FL), bi parietal diameter (BPD), as well as carried out fetal anomaly scan of all cases. Radiologist two measured the transcerebellar diameter (TCD). Both were unaware of the study as well its direction. Transcerebellar diameter was obtained by obtaining the cerebellar view by rotating the transducer in the axial plane centred on the thalamus to show the cerebellar hemispheres. This view shows the cerebellum, the cisterna magna and the cavum septum pellucidi. The cerebellum characteristically appears as two

lobules in either side of midline in the posterior cranial fossa. The widest diameter of the cerebellum is measured. Three measurements were taken in centimeter and its average was recorded in data sheet for further data analysis.

#### **Inclusion criteria**

- Normal singleton pregnancies of 15-37 weeks gestation with known last menstrual period with history of normal menstrual cycle.

#### **Exclusion criteria**

- Congenital malformations
- Multiple pregnancies
- Clinically suspected intrauterine growth retardation.
- Pregnancy with medical disorders like GDM, PIH, heart disorder, thyroid disorder.
- Bad obstetric history.

#### **Methodology for the measurement of various parameters [8, 9, 10]**

In each patient CRL was measured in the first trimester on first visit and BPD, FL and TCD were measured in the second and third trimester.

**CRL:** The Crown-rump length is measured between the fetal poles (cephalic edge) to rump and should be measured when the fetus is in neutral position. CRL can be measured reliably from 5 to 14 weeks of gestation and the fetal position like fetal flexion can cause variability up to 7 days [11, 12].

**BPD:** Measurement was taken from trans-axial sonograms of fetal head at the level of paired thalami and cavum septum pellucidi. BPD is measured from outer edge of cranium nearest the transducer to the inner edge of cranium farthest from the transducer [13].

**FL:** Measurement was taken from greater trochanter to the lateral condyle [14].

**TCD:** Transcerebellar diameter was obtained by obtaining the cerebellar view by rotating the transducer in the axial plane centred on the thalamus to show the cerebellar hemispheres. This view shows the cerebellum, the cisterna magna and the cavum septum pellucidi. The

cerebellum characteristically appears as two lobules in either side of midline in the posterior cranial fossa [15].

**Statistical analysis:** It was done using statistical package for social science (SPSS V 24). Pearson's correlation and regression coefficient was calculated between gestational age and Transverse cerebellar diameter as well as between gestational age and other fetal biometric indices. Significance level was considered at p value <0.05.

#### **Results**

In this study, 153 pregnant mothers were identified but 39 mothers were lost to follow up at 2<sup>nd</sup> and 3<sup>rd</sup> trimester and 14 mothers were excluded by exclusion criteria. So, the final result was calculated among 100 pregnant mothers.

Age of the mothers was divided into 4 groups

≤20 years – 35%

21-25 years -51%

26-30 years -12%

>30 years -2%

Mean age of the mothers was 22.16 and standard deviation was 2.93.

Distribution of mothers according to gravida

1<sup>st</sup> Gravida – 49.49%

2<sup>nd</sup> Gravida – 36.36%

3<sup>rd</sup> Gravida – 14.14%

4<sup>th</sup> Gravida – 1.1%

Distribution of mothers according to parity

Parity 0-88.88%

Parity 1-11.11%

Parity 3-1.1%

For the 100 normal pregnancy initially CRL was measured ultrasonographically in millimeters, which was compared with the gestational age estimated by LMP by using student t-test, p values and correlation analysis.

The t test showed significant association with gestational age estimated by LMP and

gestational age estimated by CRL in first trimester (**Table – 1**). Pearson correlation coefficient(r) lies between (-1 to +1). Pearson correlation coefficient(r) more close to +1 indicates more

Correlation analysis was found significant association with CRL and LMP at 1<sup>st</sup> trimester strength of association.

**Table - 1:** Distribution of study population according to gestational age by LMP and gestational age estimated by CRL in the first trimester (n=100).

Gestational age	Mean (weeks)	Standard deviation (SD)	t-value	p-value
Estimated by LMP	9.56	1.55	1.91	0.05
Estimated by CRL	9.46	1.57		

**Table - 2:** Distribution of study population for estimating gestational age according to correlation between CRL and LMP at 1<sup>st</sup> trimester.

Variables (1 <sup>st</sup> trimester)	Pearson correlation coefficient (r)	p-value
LMP	1.00	**
CRL	0.94	0.00

**Table - 3:** Regression analysis for estimating gestational age between LMP and CRL at first trimester.

			Standardised coefficients	t-value	p-value	95.0% Confidence interval for B	
	B	Standard error	Beta			Lower bound	Upper bound
(Constant)	0.741	0.315	0.944	2.355	0.021	0.117	1.366
CRL	0.932	0.033		28.388	.000	0.867	0.997

**Table - 4:** Distribution of study population for estimating gestational age according to correlation between FL, BPD and TCD with CRL at 2<sup>nd</sup> or 3<sup>rd</sup> trimester.

Variables (2 <sup>nd</sup> or 3 <sup>rd</sup> trimester)	Pearson correlation coefficient (r)	p-value
CRL	1.00	**
BPD	0.98	0.00
FL	0.95	0.00
TCD	0.99	0.00

**Table - 5:** Regression analysis for estimating gestational age between BPD and CRL, BPD and TCD at 2<sup>nd</sup> or 3<sup>rd</sup> trimester.

Variables (2 <sup>nd</sup> or 3 <sup>rd</sup> trimester)	B	Std. Error	Standardised coefficients Beta	t-value	p-value	95% confidence interval for B	
						Lower Bound	Upper Bound
(Constant)*	0.289	0.285		1.013	0.314	0.277	0.855
BPD-GA	0.095	0.059	0.092	1.615	0.010	0.022	0.212
FL-GA	0.080	0.037	0.081	2.174	0.032	0.007	0.153
TCD-GA	0.825	0.064	0.826	12.874	0.000	0.698	0.952

\*constant was CRL.

**Table - 6:** Nomogram showing BPD (mm) measurements at 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentile for the corresponding gestational age.

GA	5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
15 <sup>th</sup> week	32.0	32.0	32.0
16 <sup>th</sup> week	36.2	37	37.8
17 <sup>th</sup> week	37.2	39.0	40.9
18 <sup>th</sup> week	39.5	40.4	41.4
19 <sup>th</sup> week	42.0	42.0	42.0
20 <sup>th</sup> week	46.0	47.3	48.8
21 <sup>st</sup> week	49.3	50.4	51.9
22 <sup>nd</sup> week	54.1	55.5	56.8
23 <sup>rd</sup> week	50.6	57.0	60.7
24 <sup>th</sup> week	58.0	58.7	59.8
25 <sup>th</sup> week	60.1	62.5	66.3
26 <sup>th</sup> week	65.0	65.0	65.0
27 <sup>th</sup> week	66.0	67.0	67.8
28 <sup>th</sup> week	68.5	71.8	74.5
29 <sup>th</sup> week	73.2	75.2	77.7
30 <sup>th</sup> week	72.1	73.4	74.9
31 <sup>st</sup> week	78.0	78.4	79.0
32 <sup>nd</sup> week	75.9	78.5	80.5
33 <sup>rd</sup> week	73.7	78.8	82.0
34 <sup>th</sup> week	83.3	85.5	87.6
35 <sup>th</sup> week	86.0	86.5	87.0
36 <sup>th</sup> week	86.4	88.6	90.0
37 <sup>th</sup> week	86.6	90.3	93.1

Regression analysis was found significant association with CRL and LMP at 1<sup>st</sup> trimester (**Table - 3**).

Correlation analysis was found to significant association with CRL and other variables at 2<sup>nd</sup> or 3<sup>rd</sup> trimester. Pearson correlation coefficient (r) lies between (-1 to +1). Pearson correlation coefficient (r) more close to +1 indicates more strength of association. So, Pearson correlation coefficient (r) of TCD (0.99) > BPD (0.98) > FL (0.95) as per **Table - 4**.

Regression analysis was found significant association with CRL and other variables at 2<sup>nd</sup> and 3<sup>rd</sup> trimester (**Table - 5**).

Nomogram showing BPD (mm) measurements at 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentile for the corresponding

gestational age was as per **Table - 6**. Nomogram showing mean FL (mm) measurements at 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentile for the corresponding gestational age was as per **Table - 7**.

### Discussion

The determination of gestational age is important in obstetric for management of pregnancy and evaluation of fetal development. Higher perinatal mortality has been reported in patients whose expected date of delivery is not known. Error in the gestational age estimation can result in prematurity and post maturity. Extremes of fetal growth contribute disproportionately to overall perinatal and Infant morbidity and mortality. Accurate gestational dating is of paramount importance and the cornerstone of management of pregnancies.

**Table – 7:** Nomogram showing mean FL (mm) measurements at 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentile for the corresponding gestational age.

GA	5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
15 <sup>th</sup> week	19.0	19.0	19.0
16 <sup>th</sup> week	22.0	22.5	23.2
17 <sup>th</sup> week	21.6	23.5	24.9
18 <sup>th</sup> week	25.5	26.8	27.9
19 <sup>th</sup> week	30.1	30.2	30.8
20 <sup>th</sup> week	31.2	32.1	32.9
21 <sup>st</sup> week	35.2	35.6	36.1
22 <sup>nd</sup> week	35.3	36.5	37.8
23 <sup>rd</sup> week	38.0	41.0	46.6
24 <sup>th</sup> week	43.1	45.1	47.6
25 <sup>th</sup> week	45.1	46.9	49.4
26 <sup>th</sup> week	47.1	47.1	47.1
27 <sup>th</sup> week	50.2	50.2	50.2
28 <sup>th</sup> week	48.6	51.5	53.8
29 <sup>th</sup> week	55.0	55.3	55.9
30 <sup>th</sup> week	54.1	55.4	56.9
31 <sup>st</sup> week	58.0	58.6	59.0
32 <sup>nd</sup> week	61.4	61.9	62.3
33 <sup>rd</sup> week	65.0	65.3	65.8
34 <sup>th</sup> week	64.1	66.2	67.8
35 <sup>th</sup> week	67.0	67.6	68.0
36 <sup>th</sup> week	68.3	69.6	70.8
37 <sup>th</sup> week	71.0	72.2	74.0

Among the various clinical criteria last menstrual period (LMP) preceded by normal cycle is known to best correlate with gestational age but it is not reliable when women is not sure about her last menstrual period. Ultrasonography is routinely used for dating of pregnancy. For dating of pregnancy is CRL is the best parameter.

The other biometric parameters used for gestational age assessment are BPD, HC, AC and FL. However each of these parameters have their own limitation. The variability in predicting gestational age with these parameters goes on increasing as the pregnancy advances.

Transcerebellar diameter is another new and unique parameter for estimating the duration of gestation and it is consistently superior in

estimating gestational age in both singleton and twin gestation [16, 17].

In this study 153 normal pregnant mothers with known LMP where scanned between 9 to 13 weeks. Then these mothers were followed up in second or third trimester for gestational age estimation. BPD, FL, TCD were measured in millimetres. During this study I had lost 39 mothers to follow-up and 14 mothers were excluded by exclusion criteria so total population of this study was 100 normal pregnant mothers.

In our study there was significant correlation between estimated gestational age by CRL and estimated gestational age by known LMP (P value 0.05, t value 1.91). There was significant correlation between CRL and LMP may be due to selecting known LMP with regular menstrual

cycle but for dating of pregnancy CRL is the best parameter so we compare estimated gestational age of BPD, FL and TCD with CRL estimated age.

Nomogram was established which shows mean TCD values at 50th and 95th percentile for the corresponding gestational age. The nomogram can be used for assessing the fetal gestational age when LMP is not known and to assess any deviation from normal growth.

In this study, it was noted that early sonographic visualization of cerebellum occurred as early as 14 weeks on ultrasonography. The characteristic image of cerebellum appears as two lobules on either side of midline in the posterior cranial fossa during 14<sup>th</sup> to 20<sup>th</sup> week of gestation. TCD in millimetres is equivalent to the gestational age in weeks. After 20 weeks however, TCD in millimetres exceeds gestational age in weeks. According to another study, the normal fetal TCD exhibited a more than two fold increase in size during second half of pregnancy.

**Table - 8:** Nomogram showing mean TCD (mm) measurements at 5<sup>th</sup>, 50<sup>th</sup> and 95<sup>th</sup> percentile of the corresponding gestational age (N=100).

Gestational Age (week)	5 <sup>TH</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
15 <sup>th</sup> week	14.0	14.0	14.0
16 <sup>th</sup> week	15.0	15.0	15.0
17 <sup>th</sup> week	17.0	17.2	17.8
18 <sup>th</sup> week	18.2	18.5	18.9
19 <sup>th</sup> week	19.0	19.6	20.0
20 <sup>th</sup> week	21.1	21.3	21.9
21 <sup>st</sup> week	21.0	21.1	21.2
22 <sup>nd</sup> week	23.1	23.5	24.1
23 <sup>rd</sup> week	24.0	24.5	25.0
24 <sup>th</sup> week	25.1	25.3	25.9
25 <sup>th</sup> week	26.3	27.3	28.0
26 <sup>th</sup> week	32.0	32.2	32.2
27 <sup>th</sup> week	30.1	31.0	31.9
28 <sup>th</sup> week	29.4	32.5	35.7
29 <sup>th</sup> week	31.3	33.3	34.9
30 <sup>th</sup> week	34.2	35.0	35.9
31 <sup>st</sup> week	36.2	37.5	38.9
32 <sup>nd</sup> week	36.8	39.0	41.6
33 <sup>rd</sup> week	37.5	40.5	44.3
34 <sup>th</sup> week	39.4	42.0	46.5
35 <sup>th</sup> week	40.2	41.2	41.9
36 <sup>th</sup> week	43.4	47.0	50.6
37 <sup>th</sup> week	44.0	46.7	50.6

Goel P, et al. (2010) [18] studied the measurement of Transcerebellar diameter with ultrasonography in 50 normal fetus ranging from 14 to 40 weeks of gestational age and found that TCD showed good correlation with gestational age (correlation Coefficient = 0.91 and P value <

0.001). So, TCD is a good marker for gestational age estimation and can be used in cases who are not sure about their LMP. Similar result was found in our study. There was good correlation between TCD and gestational age ( $r = 0.99$  and  $P = 0.0001$ ).

Mcleary, et al. [19] studied the measurement of Transcerebellar diameter with ultrasonography into 25 normal fetus ranging from 15 to 39 weeks of gestational age and found it closely correlate with BPD. They proposed that the Transcerebellar diameter may be useful in estimating fetal gestational age particularly in breech presentation where extrinsic pressure may deform the skull and decrease the biparietal diameter.

Similar results were found in this study. There was good correlation between BPD and estimated age by CRL (r value= 0.98 p value= 0.001) and significant correlation with TCD ( r value 0.99 and t value 0.0001) therefore TCD may be preferred over bpd in assessing gestational age of fetus is in circumstances where head is deformed for example in moulding or dolichocephaly.

Reece, et al. [20] prospectively studied ultrasonography of 371 normal pregnant women with gestational age ranging from 13 weeks to 40 weeks they found curvilinear relationships between the transverse diameter of the cerebellum and the gestational age ( $R^2=0.948$ ,  $P=0.001$ ), biparietal diameter ( $R^2=0.956$ ,  $P=0.0001$ ), and the head circumference ( $R^2=0.969$ ,  $P=0.0001$ ). A nomogram of cerebellar measurements estimating gestational age was generated. They concluded that throughout pregnancy normative cerebellar measurements allows for estimation of gestational age that is independent of the shape of fetal head.

The result of this study is in concurrence with the above observation. In the present study there was good correlation between Transcerebellar diameter and gestational age (r-value= 0.99, p-value= 0.0001). Also good correlation was found between TCD and BPD (r value= 0.98, p-value= 0.0001). In this study TCD nomogram was established from ultrasonographically measured data which can be used for estimating the gestational age of fetus.

Smith, et al. [21] demonstrated that the fetal cerebellum can be visualized with ultrasound throughout the second trimester. Nomogram of Transcerebellar diameter measurement against the gestational age showed good correlation and narrow confidence limits.

The present study also showed similar results. It was noticed that early visualization of cerebellum with ultrasonography occurred as early as 14 weeks. Good visualization was seen in each case, however measurements were easier to perform in second and third trimester. There was good correlation between gestational age and TCD (r value= 0.99, p-value =0.0001).

Guan B [22] found curvilinear relationship between TCD and gestational age ( $R^2=0.99624$ , p value=0.0001). He concluded that the function of the TCD in the evaluation of fetal growth and development is better than any other parameter.

Similar results were obtained in present study. We noticed curvilinear relationship between TCD and gestational age (r-value 0.99, p-value 0.0001).

Orji MO, Adeyekun AA (2014) [23] reported that TCD of the fetus is studied range from 11.9 millimetre (at 13 weeks) to 59.3 millimetre at 41 weeks with a mean value of  $34.2 \pm 14.1$  millimetre. There was significant correlation between TCD and menstrual gestational age (r = 0.984, p= 0.000) TCD has a predictive accuracy of 96.9 percent with high standard error of  $\pm 10$  days.

In our study there was significant correlation found between TCD and gestational age.

Bansal M, Bansal A, et al. (2014) [24] reported that parameter which correlated most with gestational age is Transcerebellar diameter. In the normally developing fetus the Transcerebellar diameter increases with advancing gestational age. Transcerebellar diameter is a good marker for gestational age and

can be used in cases that are not sure about the dates.

R Nagesh, et al. [25] demonstrated that a linear relationship was found between TCD and fetal gestational age between 15 to 40 weeks of normal gestation ( $r=0.992$ ,  $p<0.001$ ).

The result of this study is in concurrence with the above observation. In our study, during 14<sup>th</sup> to 20<sup>th</sup> week of gestation, TCD in millimetres is equivalent to gestational age in weeks. After 20 weeks, however the TCD in millimetres exceeds gestational age in weeks. There was good correlation between TCD and gestational age ( $r$  value=0.995,  $p$  value=0.0001).

The potential importance of TCD in predicting gestational age in normal pregnancies has been thus stated.

### **Summary**

This study was done in Bankura Sammilani Medical College, Bankura and West Bengal on 100 women attending antenatal clinic. In each patient CRL was measured in first trimester on first visit and BPD, FL, TCD were measured on second or third trimester. Correlation of TCD was done with other measured parameters as well as estimated gestational age of fetus is estimated by CRL. It was found that there is good correlation between TCD and other parameters, also TCD shows good correlation with gestational age. It is better than BPD in circumstances like excessive moulding and dolichocephaly. Also TCD measurement is not fraught with problems as encountered in FL measurement.

Nomograms were derived from the ultrasonographically measured data. Thus the role of transverse cerebellar diameter measurement in assessing gestational age in normal pregnancy has been stated.

### **Conclusion**

There is good correlation between TCD and other parameters in normal pregnancies at 15 to 37 weeks of gestation.

TCD is a better parameter for gestational age assessment compared to BPD and FL. TCD measurements are not affected by conditions which affect BPD, for example moulding and dolichocephaly. FL measurements can be faulty due to include and of unossified epiphysis such problems are not encountered during TCD measurement.

The nomograms and quadratic equation derived from the measured TCD data can be used to predict gestational age of fetus.

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