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Research Article

CORRELATION BETWEEN FETAL BIOMETRY AND FETAL TRANSVERSE CEREBELLAR DIAMETER IN DETERMINATION OF GESTATIONAL AGE FROM THE 15TH WEEK OF GESTATION TO TERM IN HEALTHY WOMEN WITH UNCOMPLICATED PREGNANCY

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ABSTRACT

Objectives: The present study was conducted as an attempt to determine a correlation between the transverse cerebellar diameter (TCD) and the gestational age (GA) as determined by the last menstrual period (LMP) and other sonographic parameters such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) in healthy women with uncomplicated pregnancy between the 15th week of gestation to term, to derive normogram for estimating the GA of the fetus from ultrasonographically measured transverse cerebellar diameter.

Methods: This prospective study was conducted on 1040 healthy women with uncomplicated pregnancy between the 15th week of gestation to term. Correlation between the GA by LMP with GA by other ultrasound parameters was done using Karl Pearson's correlation(r).

Results: This study demonstrated that throughout 15–40 weeks, TCD showed a strong correlation with clinical GA with a correlation coefficient (r) of 0.967 and a statistically significant correlation. Correlation coefficients between TCD and BPD, TCD and HC, TCD and AC, and TCD and FL being 0.987, 0.987, 0.986, and 0.988, respectively, indicated statistically significant and very strong correlation. Normogram of TCD showed that there was a linear relationship between cerebellar growth and gestational age.

Conclusion: TCD can be used as a reliable parameter for the determination of GA.

Keywords: Transverse cerebellar diameter, Femur length, Abdominal circumference, Biparietal diameter, Fetal biometry, Gestational age.

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INTRODUCTION

Obstetric sonography plays an important role in the accurate determination of intrauterine gestational age (GA). Knowledge of GA is important in following ways: (i) To anticipate, normal spontaneous delivery or to plan elective delivery within the time frame of a term pregnancy (38 weeks–42 weeks), (ii) to consider invasive procedures such as chorionic villus sampling, genetic amniocentesis, and in interpretation of biochemical tests such as maternal serum alpha-fetoprotein screening, (iii) to evaluate the fetal growth, and (iv) GA influences the management decision if the fetus is diagnosed with an anomaly. Hence, all important clinical decisions are influenced by the GA [1].

A variety of sonographic fetal parameters has been shown to correlate well with gestation age. Commonly used parameters are mean sac diameter, crown-rump length, biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). Sonographic measurement of fetal BPD is a well-accepted predictor of GA. The estimation of GA from individual parameters such as the HC, AC, and FL also shows a similar variability. There are conditions such as oligohydramnios, multiple gestation, dolichocephaly, brachycephaly, and microcephaly that can alter the shape of the fetal skull which in turn can affect the BPD and increase the variability. Using all the above parameters, this variability can be reduced by 25–30% [2,3]. Multiple gestations and intrauterine growth restriction can also affect the abdominal and femoral measurement [3]. The present study was being undertaken to measure the (transverse cerebellar diameter [TCD]) to validate it as an additional morphological measurement of fetal growth with less variability [3].

Ultrasonographically, the fetal cerebellum is divided into three grades:

Grade 1: Seen predominantly up to 27 weeks of gestation [4]. Cerebellar hemispheres are rounded and lack echogenicity. Vermis is poorly developed giving the cerebellum the appearance of an eyeglass [4,5].

Grade 2: Seen predominantly from 28 to 32 weeks of gestation [4]. The vermis is more prominent and appears as an echogenic rectangular tissue connecting both hemispheres. Cerebellar hemispheres are oval and the central portion is more echogenic than the peduncles but less echogenic than the circumferential margin of the hemisphere. Cerebellum has "dumbbell" appearance [4,5].

Grade 3: Seen predominantly after 32 weeks of gestation [4]. Cerebellar hemispheres appear triangular or "fan-shaped" which are homogeneously echogenic. Echo pattern from the central portion of the hemisphere is now similar to the margin of the vermis [4,5].

The cerebellum is the last organ affected by a decrease in blood flow. In acute asphyxia, cerebellar blood flow remains unchanged as a consequence of the redistribution of cardiac output [6].

The cerebellum and posterior fossa are aligned perpendicular to the plane of maximum extrinsic compression. Hence, they are able to withstand deformation by extrinsic pressure better than the parietal bones and can be a more accurate parameter for assessing fetal growth and determination of GA [1].

METHODS

Methodology

This prospective study was conducted over a period of 12 months in 1040 healthy women with uncomplicated pregnancy between the

15th weeks of gestation to term in the Department of Radiodiagnosis at Rajindra Hospital Patiala.

Inclusion criteria

The study included 1040 healthy women with uncomplicated pregnancy between the 15th weeks of gestation to term.

Exclusion criteria

The study excluded unknown or inaccurate date of last menstrual period (LMP), irregular menstrual cycles, oligohydramnios, polyhydramnios, diabetic mother, pregnancy-induced hypertension, dolichocephalic skull, multiple gestations, fetal chromosomal abnormalities, fetal anomalies, intrauterine growth restriction, and any other known maternal and fetal abnormality.

Technique

All relevant clinical history was obtained and the LMP was confirmed. Transabdominal ultrasonography was performed with a pregnant patient in a supine position with mid-low frequency probe (2–5 MHz) using PHILIPS HD11XE ultrasound scanner. In all the pregnant patients, following parameters were measured – BPD, HC, AC, FL, and TCD. GA for the measured TCD was obtained from the reference chart "Predicted menstrual age for transverse cerebellar diameter (TCD) of 14 mm–56 mm" by Hill *et al*., in his study "TCD as a predictor of menstrual age" in 1990 [7].

Statistical analysis

All the relevant collected data were compiled on the master chart and subjected to analysis using the Pearson correlation and regression technique and descriptive studies were presented in terms of mean, standard deviation, and percentage.

Ethical considerations

Ethical clearance was received from the Research and Ethical Committee, Government Medical College, Patiala. The study was approved by the Faculty of Medical Sciences, Baba Farid University of Health Sciences, Faridkot.

Table 1: Parity distribution

Parity	Number of cases	Percentage
P0	611	58.75
P1	298	28.65
P2	65	6.25
P3	42	4.04
P4	24	2.31
Total	1040	100.0

RESULTS

The present study consisted of 1040 healthy women with uncomplicated pregnancies between the 15th week of gestation to term.

Age distribution

The majority of females were from the age group of 25–30 years, that is, 466 females (44.81%). Three hundred and sixteen females (30.38%) were between 20 and 25 years, 237 females (22.79%) were in the age group of 30–35 years, and only 21 females were in the age group of more than 35 years.

Table 2: Correlation between TCD gestational age and BPD gestational age

Gestational age group according to LMP (in weeks)	TCD		BPD		Pearson's correlation coefficient (r)	p-value
	Mean gestational age (in weeks)	Standard deviation	Mean gestational age (in weeks)	Standard deviation		
15–20	18.12	1.64	18.55	1.63	0.864	<0.001
20–25	21.47	2.10	21.76	1.95	0.875	<0.001
25–30	26.98	2.35	27.34	2.49	0.912	<0.001
30–35	31.75	1.77	31.84	1.74	0.817	<0.001
35–40	35.01	2.24	34.97	2.19	0.830	<0.001

TCD: Transverse cerebellar diameter

Table 3: Correlation between TCD gestational age and HC gestational age

Gestational age group according to last menstrual period (in weeks)	TCD		HC		Pearson's correlation coefficient (r)	p-value
	Mean gestational age (in weeks)	Standard deviation	Mean gestational age (in weeks)	Standard deviation		
15–20	18.12	1.64	18.49	1.62	0.854	<0.001
20–25	21.47	2.10	21.61	1.95	0.873	<0.001
25–30	26.98	2.35	27.31	2.42	0.901	<0.001
30–35	31.75	1.77	31.78	1.79	0.810	<0.001
35–40	35.01	2.24	35.10	2.08	0.840	<0.001

HC: Head circumference, TCD: Transverse cerebellar diameter

Table 4: Correlation between TCD gestational age and AC gestational age

Gestational age group according to last menstrual period (in weeks)	TCD		AC		Pearson's correlation Coefficient (r)	p-value
	Mean gestational age (in weeks)	Standard deviation	Mean gestational age (in weeks)	Standard deviation		
15–20	18.12	1.64	18.46	1.64	0.854	<0.001
20–25	21.47	2.10	21.64	1.93	0.863	<0.001
25–30	26.98	2.35	26.95	2.40	0.901	<0.001
30–35	31.75	1.77	31.60	1.84	0.799	<0.001
35–40	35.01	2.24	34.87	1.97	0.840	<0.001

TCD: Transverse cerebellar diameter, AC: Abdominal circumference

Table 5: Correlation between TCD gestational age and FL gestational age

Gestational age group according to last menstrual period (in weeks)	TCD		FL		Pearson's correlation coefficient (r)	p-value
	Mean Gestational Age (in weeks)	Standard deviation	Mean gestational age (in weeks)	Standard deviation		
15–20	18.12	1.64	18.38	1.65	0.842	<0.001
20–25	21.47	2.10	21.69	1.89	0.878	<0.001
25–30	26.98	2.35	27.14	2.42	0.909	<0.001
30–35	31.75	1.77	31.80	1.73	0.824	<0.001
35–40	35.01	2.24	35.17	1.96	0.862	<0.001

TCD: Transverse cerebellar diameter, FL: Femur length

Table 6: Correlation between TCD gestational age and clinical gestational age

Gestational age group according to last menstrual period (in weeks)	TCD		Clinical gestational age		Pearson's Correlation Coefficient (r)	p-value
	Mean gestational age (in weeks)	Standard deviation	Mean gestational age (in weeks)	Standard deviation		
Nbbn 15–20	18.12	1.64	18.41	1.16	0.574	<0.001
20–25	21.47	2.10	22.06	1.42	0.768	<0.001
25–30	26.98	2.35	27.33	1.50	0.576	<0.001
30–35	31.75	1.77	32.59	1.36	0.656	<0.001
35–40	35.01	2.24	37.04	1.28	0.316	<0.001

TCD: Transverse cerebellar diameter

Table 7: Correlation coefficient of TCD with CGA, BPD, HC, AC, and FL in both second and third trimesters

Combination of parameters	Pearson's correlation coefficient (r)	Significance
TCD vs. CGA	0.967	<0.001
TCD vs. BPD	0.987	<0.001
TCD vs. HC	0.987	<0.001
TCD vs. AC	0.986	<0.001
TCD vs. FL	0.988	<0.001

TCD: Transverse cerebellar diameter, BPD: Biparietal diameter, HC: Head circumference, AC: Abdominal circumference, FL: Femur length, CGA: Clinical gestational age

Table 8: Correlation coefficient of CGA with BPD, HC, AC, FL, and TCD in both second and third trimesters

Combination of parameters	Pearson's correlation coefficient (r)	Significance
CGA vs. BPD	0.964	<0.001
CGA vs. HC	0.967	<0.001
CGA vs. AC	0.967	<0.001
CGA vs. FL	0.970	<0.001
CGA vs. TCD	0.967	<0.001

TCD: Transverse cerebellar diameter, BPD: Biparietal diameter, HC: Head circumference, AC: Abdominal circumference, FL: Femur length,
TCD: Transverse cerebellar diameter, CGA: Clinical gestational age

Gravidity distribution

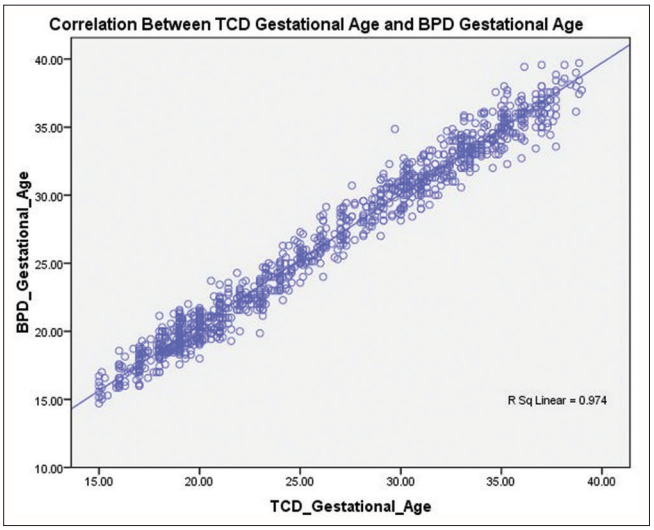
Out of 1040 pregnant women, 52.2% were primigravida and 47.8% were multigravida.

Parity distribution

In the present study, the parity of 1040 pregnant women ranged from parity zero to parity four (Table 1).

Trimester distribution

In our study, out of 1040 pregnant women, 515 (49.52%) pregnant women were in the second trimester and 525 (50.48%) were in the third trimester.



Graph 1: A scatter diagram showing the correlation and regression analysis of the TCD with biparietal diameter in the second and third trimesters. Here, TCD is correlated with BPD by 97.4%. TCD: Transverse cerebellar diameter, BPD: Biparietal diameter

In our study at 15–20 weeks, 20–25 weeks, 25–30 weeks, 30–35 weeks, and 35–40 weeks age groups, mean predicted GA by TCD and BPD was within range. Correlation coefficient between TCD and BPD in above age groups indicates statistically significant (p<0.001) and good strength of correlation (Table 2).

In our study at 15–20 weeks, 20–25 weeks, 25–30 weeks, 30–35 weeks, and 35–40 weeks age groups, the mean predicted GA by TCD and HC was within range. Correlation coefficient between TCD and HC in the above age groups indicates statistical significance (p<0.001) and good strength of correlation (Table 3).

In our study at 15–20 weeks, 20–25 weeks, 25–30 weeks, 30–35 weeks, and 35–40 weeks age groups, the mean predicted GA by TCD and AC was within range. Correlation coefficient between TCD and AC in the

Table 9: Predicted gestational age for TCD of 14–56 mm

Cerebellum (mm)	Mean TCD gestational age (in weeks)	Standard deviation	Cerebellum (mm)	Mean TCD gestational age (in weeks)	Standard deviation
14	15.198	0.3074	35	29.832	0.1769
15	16.000	0.0000	36	30.153	1.1629
16	16.229	0.3597	37	31.068	0.2865
17	17.236	0.3211	38	31.469	0.1838
18	18.239	0.2647	39	32.105	0.1607
19	19.227	0.3120	40	32.571	0.1157
20	20.204	0.2653	41	33.071	0.1001
21	21.206	0.2937	42	33.543	0.1230
22	22.232	0.2475	43	34.138	0.1502
23	23.127	0.2350	44	34.649	0.1093
24	23.800	0.0821	45	35.146	0.1441
25	24.140	0.0000	46	35.813	0.4011
26	24.148	0.2869	47	36.027	0.1883
27	24.760	0.2471	48	36.293	0.2192
28	25.209	0.5238	49	36.823	0.0750
29	25.976	0.1524	50	37.071	0.2362
30	26.226	0.7845	51	37.452	0.2541
31	27.257	0.2289	52	37.710	0.0000
32	28.000	0.0000	54	37.807	0.5774
33	28.719	0.3823	55	38.734	0.1537
34	29.548	0.2899	56	39.000	0.0000

TCD: Transverse cerebellar diameter

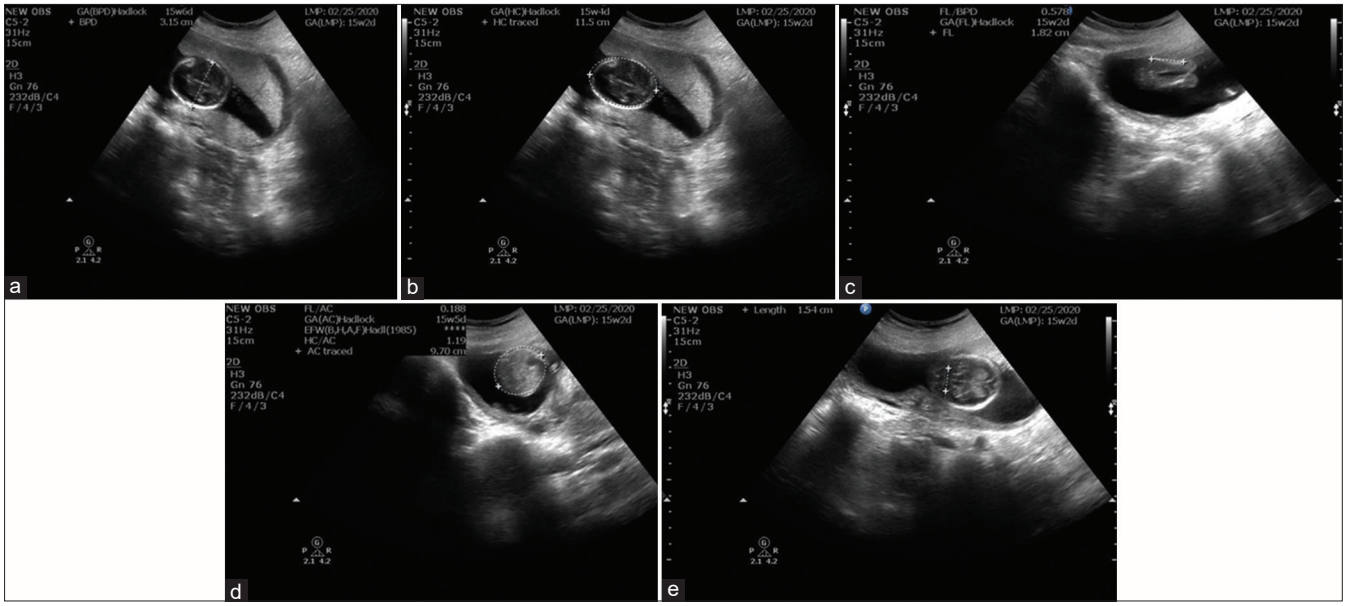


Fig. 1: A 23-year-old patient presented with amenorrhea of 15 weeks 2 days. (a) GA by biparietal diameter was 15 weeks 6 days. (b) GA by head circumference was 15 weeks 4 days. (c) GA by femur length was 15 weeks 2 days. (d) GA by abdominal circumference was 15 weeks 5 days. (e) GA by transverse cerebellar diameter was 15 weeks 4 days. GA: Gestational age

above age groups indicated statistically significant (p<0.001) and good strength of correlation (Table 4).

In our study at 15–20 weeks, 20–25 weeks, 25–30 weeks, 30–35 weeks, and 35–40 weeks age groups, the mean predicted GA by TCD and FL was within range. The correlation coefficient between TCD and FL in above age groups indicates statistically significant (p<0.001) and good strength of correlation (Table 5).

In our study at 15–20 weeks, 20–25 weeks, 25–30 weeks, 30–35 weeks, and 35–40 weeks age groups, mean predicted GA by TCD and mean clinical GA (CGA) by LMP were within range.

The correlation coefficient between TCD and CGA in the above age groups indicates statistically significant (p<0.001) and moderate strength of correlation (Table 6).

The above-shown Table 7 reveals the association between the fetal measurements and TCD. The correlation for TCD versus BPD, HC, AC, and FL was almost similar (r: 0.987, 0.987, 0.986, and 0.988, respectively). The correlation was best for TCD versus FL (r: 0.988) and least for TCD versus CGA (r: 0.967). All the correlations were statistically significant.

This Table 8 shows the association between fetal measurements and CGA. The correlation for CGA versus BPD, HC, AC, FL, and TCD was almost similar (r: 0.964, 0.967, 0.967, 0.970, and 0.967, respectively). The correlation was best for CGA versus FL (r: 0.970). All the correlations were statistically significant.

In our study, TCD normogram was established from ultrasonographically measured data of TCD from 14 to 56 mm (Table 9).

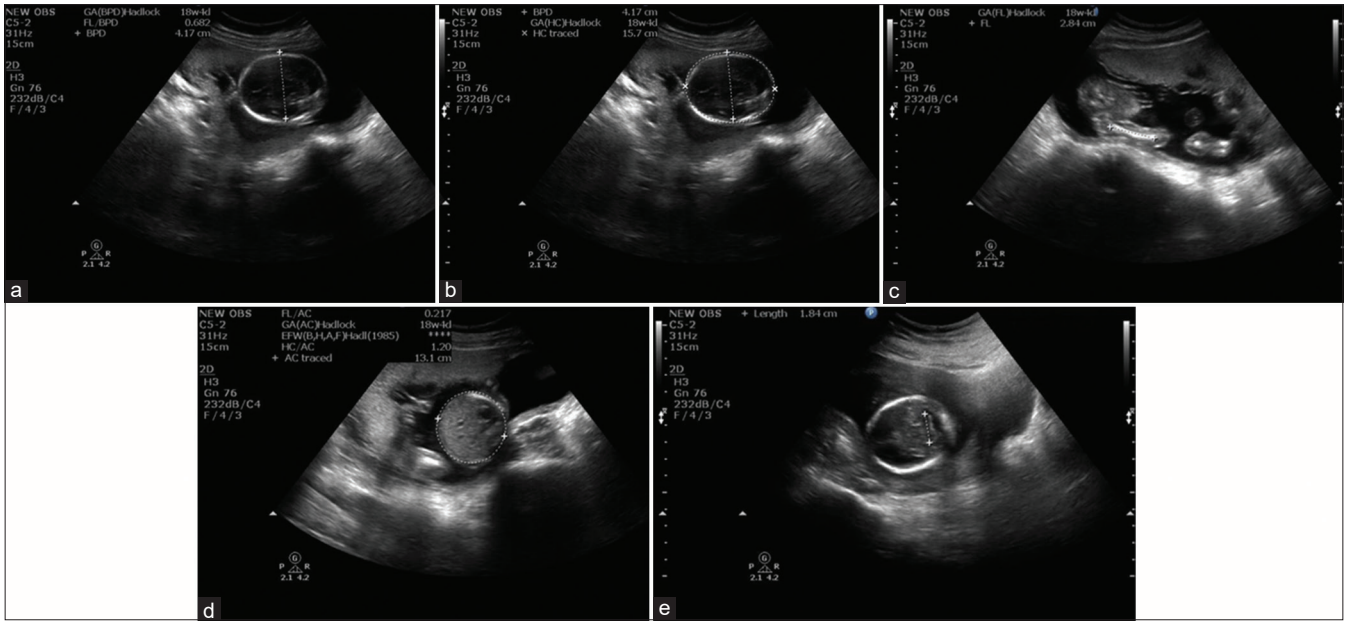


Fig. 2: A 31-year-old patient presented with amenorrhea of 18 weeks 3 days. (a) GA by biparietal diameter was 18 weeks 4 days. (b) GA by head circumference was 18 weeks 4 days. (c) GA by femur length was 18 weeks 4 days. (d) GA by abdominal circumference was 18 weeks 4 days. (e) GA by transverse cerebellar diameter was 18 weeks 4 days. GA: Gestational age

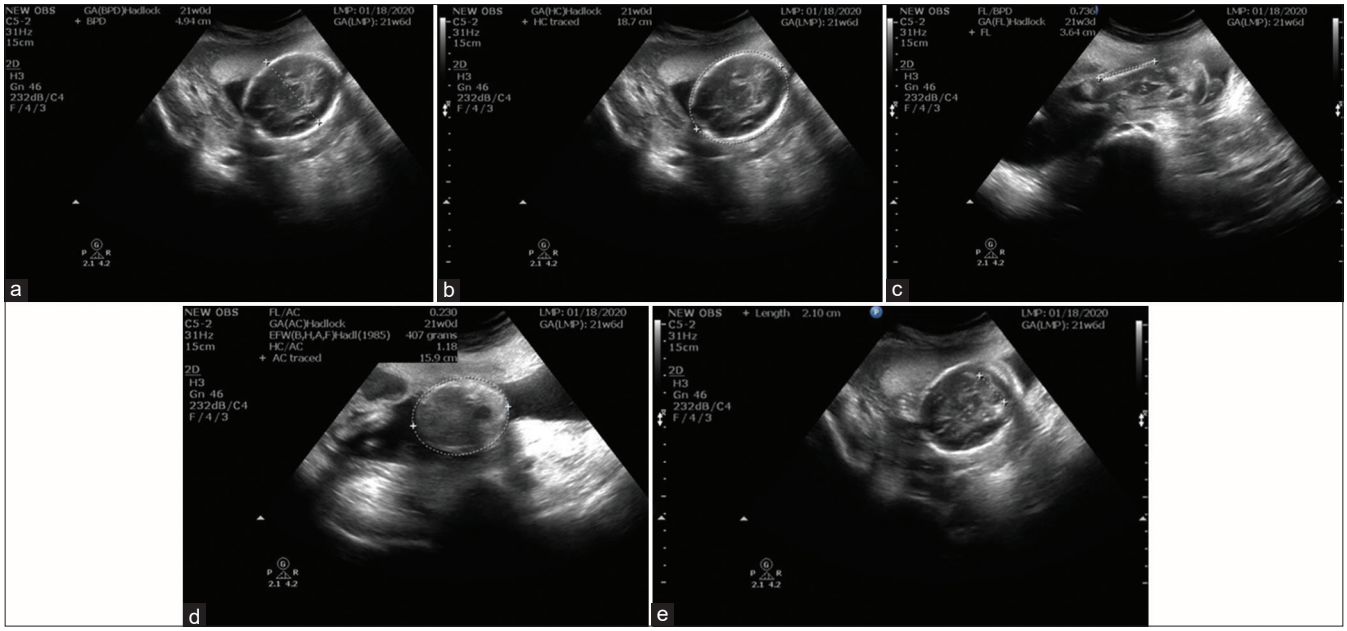


Fig. 3: A 23-year-old patient presented with amenorrhea of 21 weeks 6 days. (a) GA by biparietal diameter was 21 weeks 0 day. (b) GA by head circumference was 21 weeks 0 day. (c) GA by femur length was 21 weeks 3 days. (d) GA by abdominal circumference was 21 weeks 0 day. (e) GA by transverse cerebellar diameter was 21 weeks 0 day. GA: Gestational age

DISCUSSION

In our study, cases were divided into five groups based on GA according to LMP, that is, 15–20 weeks, 20–25 weeks, 25–30 weeks, 30–35 weeks, and 3–40 weeks.

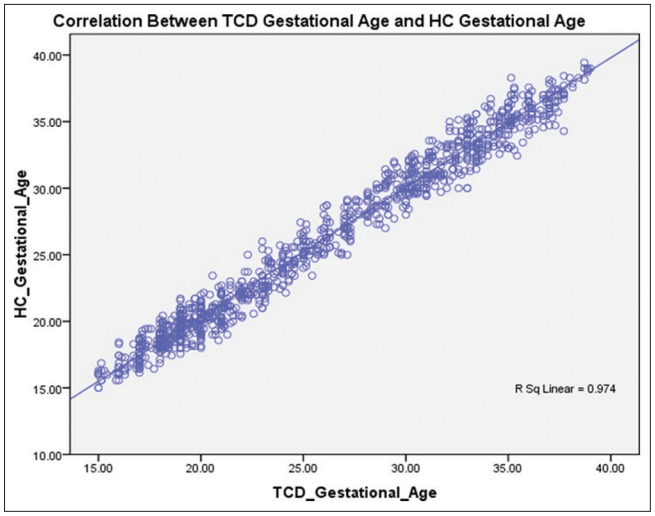
At 15–20 weeks, mean actual GA by LMP was 18.41 weeks and the mean predicted GA by TCD was 18.12 weeks, by BPD 18.55 weeks, by HC was 18.49 weeks, by AC was 18.46 weeks, and by FL was 18.38 weeks (Fig. 2).

At 20–25 weeks, mean actual GA by LMP was 22.06 weeks and mean predicted GA by TCD was 21.47 weeks, by BPD was 21.76 weeks, by HC was 21.61 weeks, by AC was 21.64 weeks, and by FL was 21.69 weeks (Fig. 3).

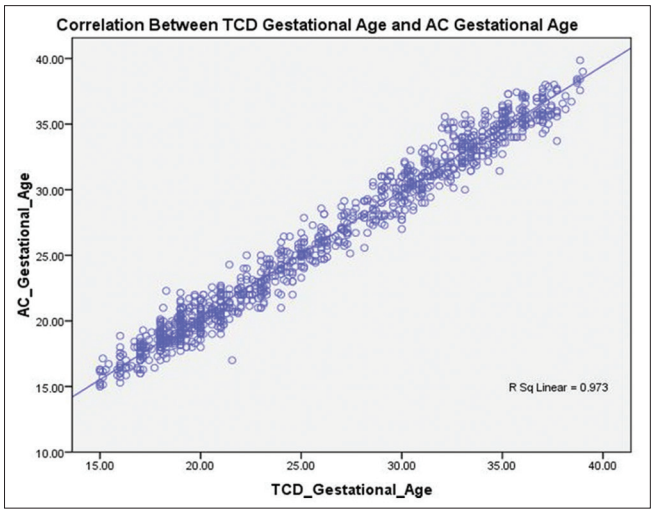
At 25–30 weeks, mean actual GA by LMP was 27.33 weeks and the mean predicted GA by TCD was 26.98 weeks, by BPD was 27.34 weeks, by HC was 27.31 weeks, by AC was 26.95 weeks, and by FL was 27.14 weeks.

At 30–35 weeks, mean actual GA by LMP was 32.59 weeks and the mean predicted GA by TCD was 31.75 weeks, by BPD was 31.84 weeks, by HC was 31.78 weeks, by AC was 31.60 weeks, and by FL was 31.80 weeks.

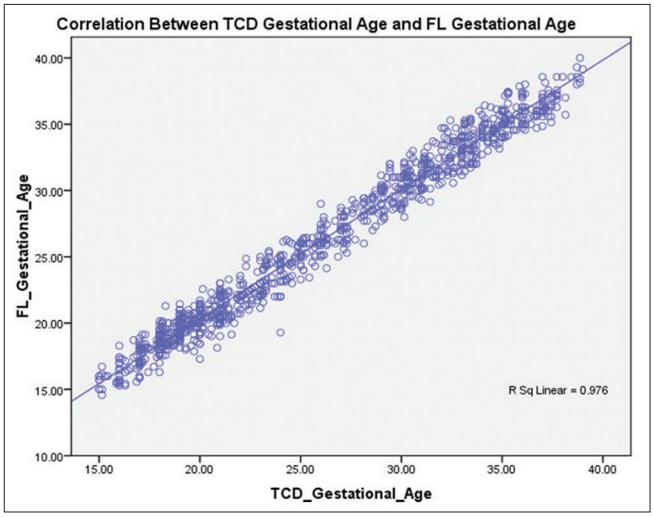
At 35–40 weeks, mean actual GA by LMP was 37.04 weeks and the mean predicted GA by TCD was 35.01 weeks, by BPD was 34.97 weeks, by HC was 35.10 weeks, by AC was 34.87 weeks, and by FL was 35.17weeks.



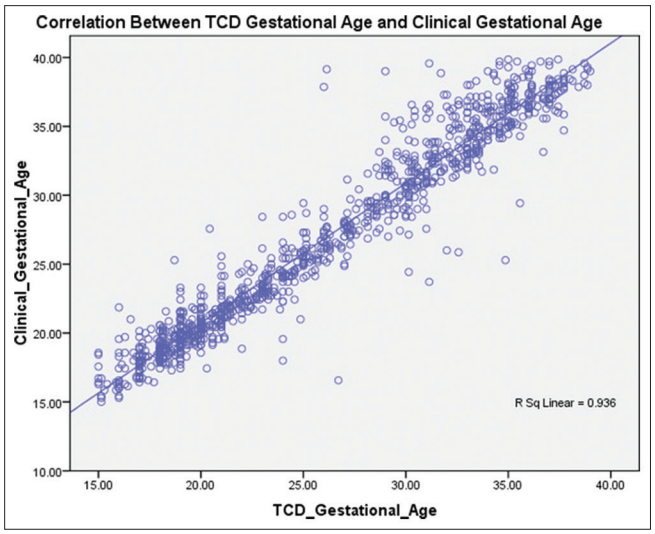
Graph 2: A scatter diagram showing the correlation and regression analysis of the TCD with HC in the second and third trimesters. Here, TCD is correlated with HC by 97.4%. TCD: Transverse cerebellar diameter, HC: Transverse cerebellar diameter



Graph 3: A scatter diagram showing the correlation and regression analysis of the TCD with AC in the second and third trimesters. Here, TCD is correlated with AC by 97.3%. TCD: Transverse cerebellar diameter, AC: Abdominal circumference



Graph 4: A scatter diagram showing the correlation and regression analysis of the TCD with FL in the second and third trimesters. Here, TCD is correlated with FL by 97.6%. TCD: Transverse cerebellar diameter, FL: Femur length



Graph 5: A scatter diagram showing the correlation and regression analysis of the TCD with CGA in the second and third trimesters. Here, TCD is correlated with CGA by 93.6%. TCD: Transverse cerebellar diameter, CGA: Clinical gestational age

The correlation coefficient between CGA and TCD was r=0.967 (p<0.001), between CGA and BPD was r=0.964 (p<0.001), between CGA and HC was r=0.967 (p<0.001), between CGA and AC was r=0.967 (p<0.001), and between CGA and FL was r=0.970 (p<0.001), indicating statistically significant and very good strength of correlation.

Similar results had been reported by Madhumitha and Suma [3] and Nikolov *et al.* [8].

In our study, a linear relationship was found during the second and third trimester between the cerebellar growth measured in mm (millimeters) and the GA in weeks. This relationship of fetal cerebellar growth and GA was statistically significant (Graph 1). Similar relationship was demonstrated by Bansal *et al.* [9], Reddy *et al.* [10], Dashottar *et al.* [11], Kothan *et al.* [12], and Prasad *et al.* [13].

In the present study, scatter diagram plotted (Graphs 2 and 3) between TCD and BPD, HC, AC, FL, and CGA showed a linear relation of TCD with BPD, TCD with HC, TCD with AC, TCD with FL, and TCD with CGA, making the present study statistically significant.

Similarly in studies done by Agrawal *et al.* [14] and Sandeep and Parthasarathi [1], Scatter diagram between GA and TCD; and TCD and BPD, HC, AC, FL, CGA in weeks showed a linear relationship between GA and TCD, which was statistically significant (Graphs 4 and 5).

In this study, TCD normogram was established from ultrasonographically measured data which can be used for estimating the GA of fetus. The values were compared with a study conducted by Hill *et al.* [7] and it was observed that the values reported in our study were slightly smaller. This is probably due to the difference in the ethnic origin of patients.

In this study, ultrasound visualization of cerebellum was around 14–15 weeks of gestation (Fig. 1). The characteristic image of the cerebellum by ultrasonography appears as two lobules on either side

of the midline, located in the posterior cranial fossa. We noticed in our study, the TCD in millimeters was almost equal to GA in weeks up to 23 weeks, thereafter TCD in millimeters exceeded GA in weeks and reached up to 56 mm. Similar results had been reported by Hill *et al*.[7]

In the present study, the correlation between TCD and BPD, TCD and HC, TCD and AC, and TCD and FL with correlation coefficients being 0.987, 0.987, 0.986, and 0.988, respectively, showing statistically significant and very good strength of correlation.

Mathur and Chauhan [15] found a similar correlation between TCD and BPD (r=0.981), between TCD and HC (r=0.918), between TCD and AC (r=0.9513), and between TCD and FL (r=0.964) which was statistically significant with p<0.001.

Sandeep and Parthasarathi [1] studied ultrasonography of 100 normal pregnant women with GA ranging from 28 to 40 weeks of pregnancy and they found that regression analysis between fetal TCD and CGA (R^2=83.9%), TCD and BPD (R^2=81.7%), TCD and HC (R^2=81.5%), TCD and AC (R^2=83.2%), and TCD and FL (R^2=87.7%) was statically significant. The results of this study are in concurrence with the above observation. In the present study, from regression analysis, a strongly significant relationship had been observed between fetal TCD and CGA (R^2=93.6%), TCD and BPD (R^2=97.4%), TCD and HC (R^2=97.4%), TCD and AC (R^2=97.3%), and TCD and FL (R^2=97.6%).

CONCLUSION

The present study shows that incorporating the results of TCD with some combination of other fetal biometric parameters, such as BPD, HC, AC, and FL can help to improve accurate gestational dating. Hence, TCD can be used as a reliable parameter for the determination of gestational age.

AUTHOR CONTRIBUTION(S)

Amanjeet Kaur: Data curation; Formal analysis; Writing-original draft; Writing-review and editing. Amita: Data curation; Formal analysis; Writing-original draft; Writing-review and editing. Suman Yadav: Conceptualization; Formal analysis; Investigation; Methodology; Writing original draft; Writing-review and editing.

DECLARATION OF CONFLICT OF INTEREST

No author has any affiliation (financial or otherwise) with a pharmaceutical, medical device, or communications organization.

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