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Transcerebellar Diameter: An Independent Marker for Estimation of Gestational Age

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Abstract
Cerebellum is a posterior cranial fossa structure, appears at the end of 5th week of gestational age. The cerebellum is easily visualised sonographically surrounded by petrous ridges and occipital bone. Measurement & demonstration of fetal cerebellum is a unique parameter of fetal brain growth & also useful in determination of gestational age. The prospective study was carried out on 186 antenatal patients (20-40 years of age) between 14-40 weeks of pregnancy attending the clinic for routine ultrasound examination. Patients who had any complication of pregnancy were not included in the study. Ultrasonographic measurement of Transverse cerebellar diameter (TCD) was done to assess the gestational age. Mean TCD was 17.77 in 14-20 weeks of gestation, 28.40 mm in 21-30 weeks and 40.00 mm in 31-40 weeks. Regression analysis indicates a significant relationship between TCD and gestational age, indicating that TCD is a good marker for estimation of gestational age.
Keywords: *Fetuse, Gestational Age(GA), Transeverse Cerebellar Diameter (TCD), Ultrasonography (USG).*

Introduction

Historically one had to rely on the patient's history and clinical signs to determine gestational age. An early pelvic examination, onset of quickening and fundal height from the umbilicus were other methods used. Important landmarks in determining the gestational age include the first day of last menstrual period, the date of last ovulation or the date of conception if precisely known as in IVF cases.[1] Estimating gestational age is very important to an obstetrician for diagnosis of growth disorders, in assessment of wrong dates or forgotten dates and timing of delivery either by induction or caesarean section.[2] Ultrasound assessment for gestational age (GA) is the cornerstone in modern obstetrics and continues to remain an important component in the management of pregnancies. Many parameters are being used for establishing GA for example, biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL). Recently the evaluation of the posterior fossa of the fetal cranium has been accepted as part of routine obstetrical estimations. While the BPD was the first fetal parameter to be clinically utilized in the determination of fetal age in the second trimester,more recent studies have evaluated the use of several other parameters like foot length, ear size, orbital diameters, cerebellum diameter ,renal diameter etc.[3,4,5,6] Cases with dolichocephaly or brachycephaly, TCD may be a more reliable predictor than biparietal diameter since the posterior fossa is not affected by external

pressure including fetal malposition, breech presentation or oligohydramnios, which may induce distortion of the fetal head.[7] TCD can reliably be used in cases of femur achondroplasia where femur length is unreliable. The present study was undertaken to evaluate the usefulness of trans cerebellar diameter as against other conventional parameters such as biparietal diameter and femur length in normal pregnant mother between 15-40 weeks for accurate estimation of gestational age.

Material & Methods

The study was conducted in the Department of Radio-Diagnosis, S.C.B. Medical College, Cuttack between the period September 2015 to September 2017. The prospective study was carried out on 186 pregnant women between 20-40 yrs of age, attending the clinic for routine ultrasound examination and antenatal check-up between 14 to 40 weeks of pregnancy & the cases were divided into three groups. (14 to 20 weeks, 21-30 weeks and 31-40 weeks).Normal singleton pregnancies of 14 & 40 wks gestation with known lastmenstrual period with no associated risk factors were included in our study. Pregnancy with congenital malformation, multiple pregnancies, suspected IUGR, patients with unknown LMP were excluded from our study. The USG machine "Phillps HD 7" with a transducer of 3-5 MHz was used during the study. An informed consent from all the patients was taken and. An ultrasound examination was performed with the patient in the supine position and all parameters were obtained including biparietal diameter, head circumference, abdominal circumference, the fetal femur length and the trans-cerebellar diameter. The BPD was taken as cross section parallel to the cantho-meatal line and slightly above it, which includes the falx, thalamus and the most important cavum septum pellucidum and 2/3rds from the occiput, intersecting it in the midline, extending as a line from the anterior to posterior aspect of the skull interrupted in the mid line by slit like third ventricle and posteriorly by the thalamus. BPD is measured as the largest perpendicular line to the mid line echo, from the midline of the proximal skull to the midline of the distal skull. Fetal femoral length was obtained from the greater trochanter to the middle of the lateral condyle. Abdominal circumference was taken in the plane showing umbilical vein perpendicular to the fetal spine and the stomach bubble. Head circumference was taken in the BPD plane. The trans-cerebellar diameter was obtained by the following methods. The landmarks of the thalamus and the cavum pellucidum and third ventricle were identified. Then by slightly rotating the transducer below the thalamic plane, the posterior fossa was revealed with the characteristic butterfly like appearance of the cerebellum. The cisterna magna just posterior to the cerebellum. These examinations were performed between 15 to 40 weeks of gestation. The statistical evaluation between fetal transverse cerebellar diameter and gestational age was assessed.

Observation

Table -1: Age Distribution of Patients

Age Group	No of Patients	Percentage
15-25 YRS	74	39
26-35 YRS	108	58
35-45 YRS	4	2

Table -2: Distribution According to Parity

Parity	No Of Patients	Percentage
0	64	34
1	82	44
2	36	19
3	3	2
4	1	1

Table 3: Biparietal Diameter vs Gestational Age

Gestational Age in Weeks	BPD in CM	Standard Deviation in CM
14	2.49	0
15	3.09	0 .69
16	3.45	0. 57
17	3.79	0. 57
18	3.91	0 .27
19	4.20	0
20	3.75	0 .78
21	4.85	0 .17
22	5.28	1 .19
23	6.07	0 .76
24	5.63	0 .39
25	5.74	0 .50
26	6.58	0 .46
27	7.03	0 .21
28	6.90	0 .24
29	6.90	0 .34
30	7.38	0 .31
31	7.57	0 .08
32	7.86	0 .61
33	8.20	0 .18
34	7.96	0 .39
35	8.40	0 .48
36	8.50	0 .30
37	8.33	0 .40
38	9.00	0 .39
39	8.56	0 .16
40	8.80	0 .12

Fig-1

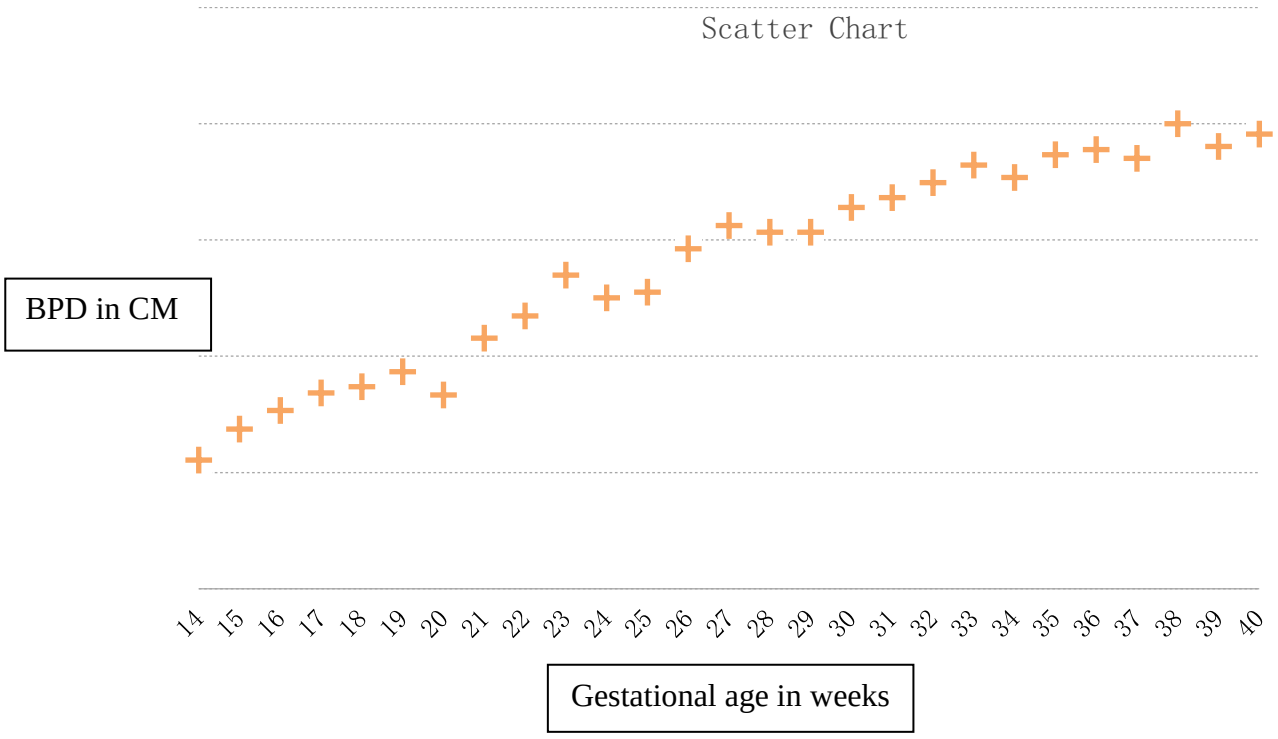

Table 4: Head Circumference vs Gestational Age

Gestational Age in Weeks	Head Circumference in CM	Standard Deviation in CM
14	9.04	0
15	10.87	1 .68
16	13.12	1 .62
17	15.25	1 .16
18	15.04	0 .43
19	16.20	0
20	14.35	2 .98
21	18.50	0 .23
22	20.88	3 .43
23	23.40	3 .20
24	21.70	1 .20
25	21.60	1 .70
26	25.07	1 .89
27	26.70	1 .01
28	25.80	1 .47
29	26.55	0 .28
30	27.78	1 .27
31	24.50	2 .66
32	29.50	2 .05
33	30.10	0 .85
34	29.87	1 .23
35	31.16	1 .61
36	31.46	1 .83
37	32.47	1 .39
38	33.80	0 .95
39	32.50	0 .23
40	31.90	0 .35

Fig-2

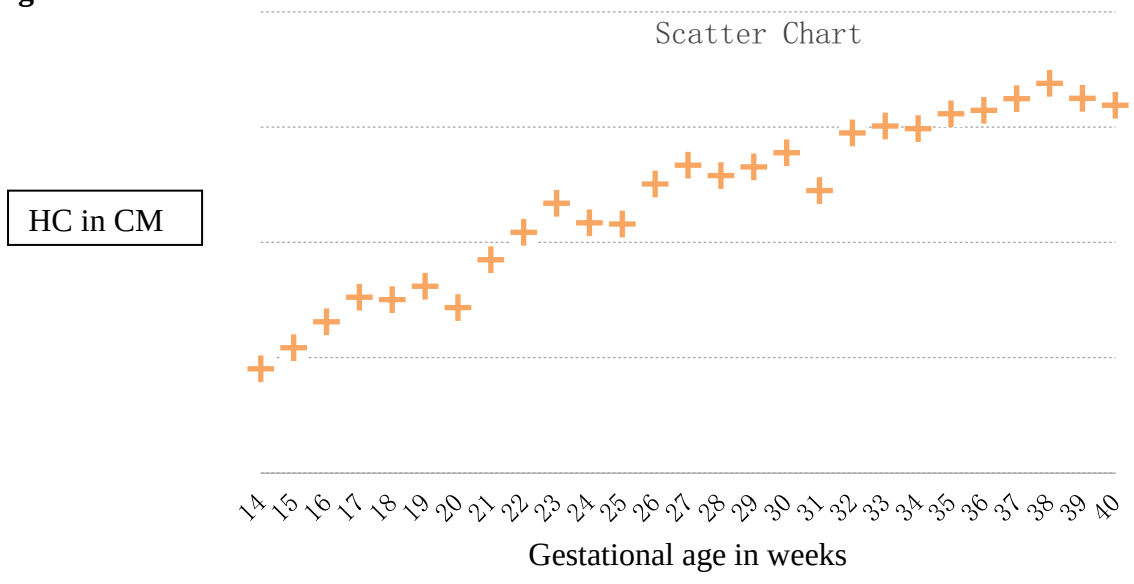

Table 5: Abdominal Circumference s Gestational Age

Gestational Age in Weeks	Abdominal Circumference in CM	Standard Deviation in CM
14	7.54	0
15	9.13	1 .83
16	10.20	2 .46
17	12.90	1 .78
18	12.98	0 .33
19	13.30	0
20	12.12	3 .50
21	15.65	0. 98
22	17.88	2 .86
23	20.16	2 .59
24	19.50	0 .87
25	18.96	3 .37
26	22.53	3 .75
27	22.80	1 .55
28	23.00	0 .05
29	23.45	2 .13
30	24.90	1 .49
31	26.50	0 .11
32	27.60	2 .47
33	30.10	1 .71
34	28.90	1 .22
35	30.13	2 .03
36	31.74	2 .61
37	31.10	1 .56
38	32.60	1 .82
39	31.00	0 .81
40	31.75	0 .40

Fig-3

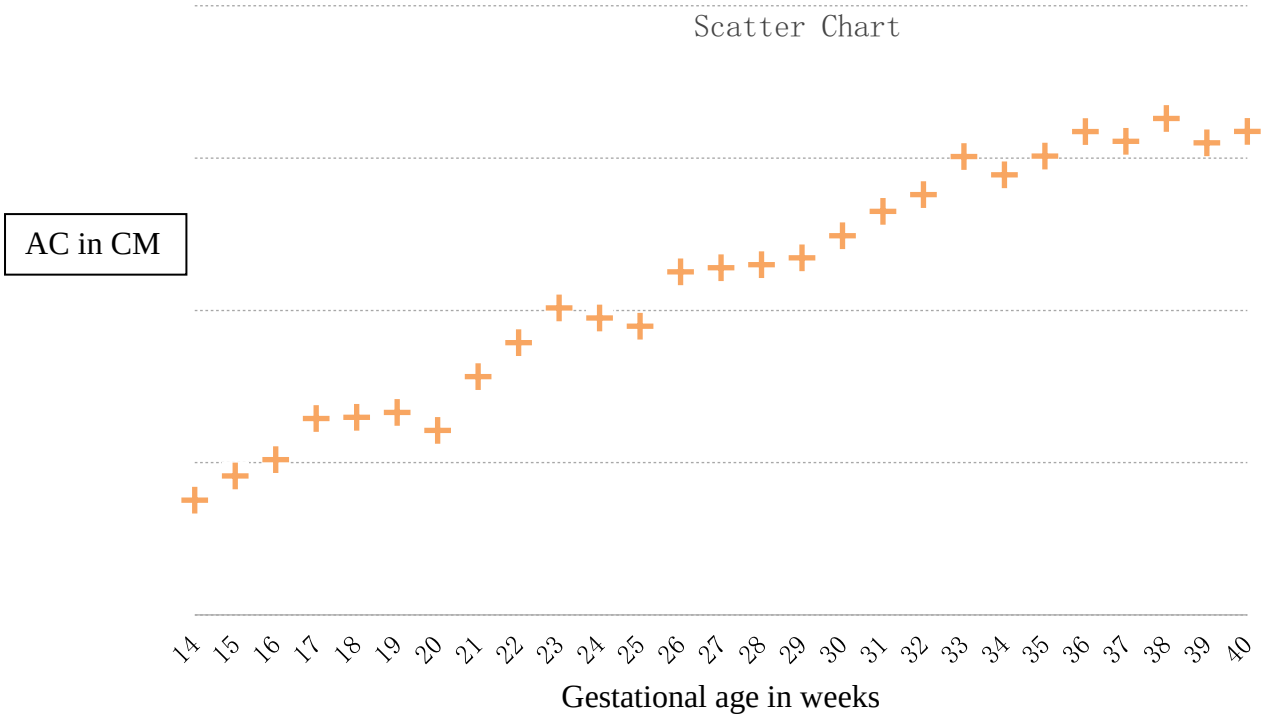

Table 6: Femur Length Vs Gestational Age: Pearson correlation coefficient (R) =0.949 Coefficient ofdetermination (R^2) =0.899P value <0.00001

Gestational Age in Weeks	Femur Length in CM	Standard Deviation in CM
14	1.30	0
15	1.66	0 .56
16	2.09	0 .29
17	2.85	0 .63
18	2.84	0 .31
19	3.00	0
20	2.39	0 .84
21	3.65	0 .17
22	3.78	0 .63
23	4.36	0 .40
24	4.21	0 .39
25	4.16	0 .41
26	4.82	0 .83
27	5.16	0 .24
28	4.77	0 .52
29	5.15	0 .06
30	5.69	0 .41
31	5.70	0
32	6.20	0 .43
33	6.18	0 .06
34	6.50	0 .27
35	6.61	0 .42
36	6.77	0 .24
37	7.16	0 .18
38	6.77	0 .63
39	7.16	0 .16
40	6.95	0 .06

Fig-4

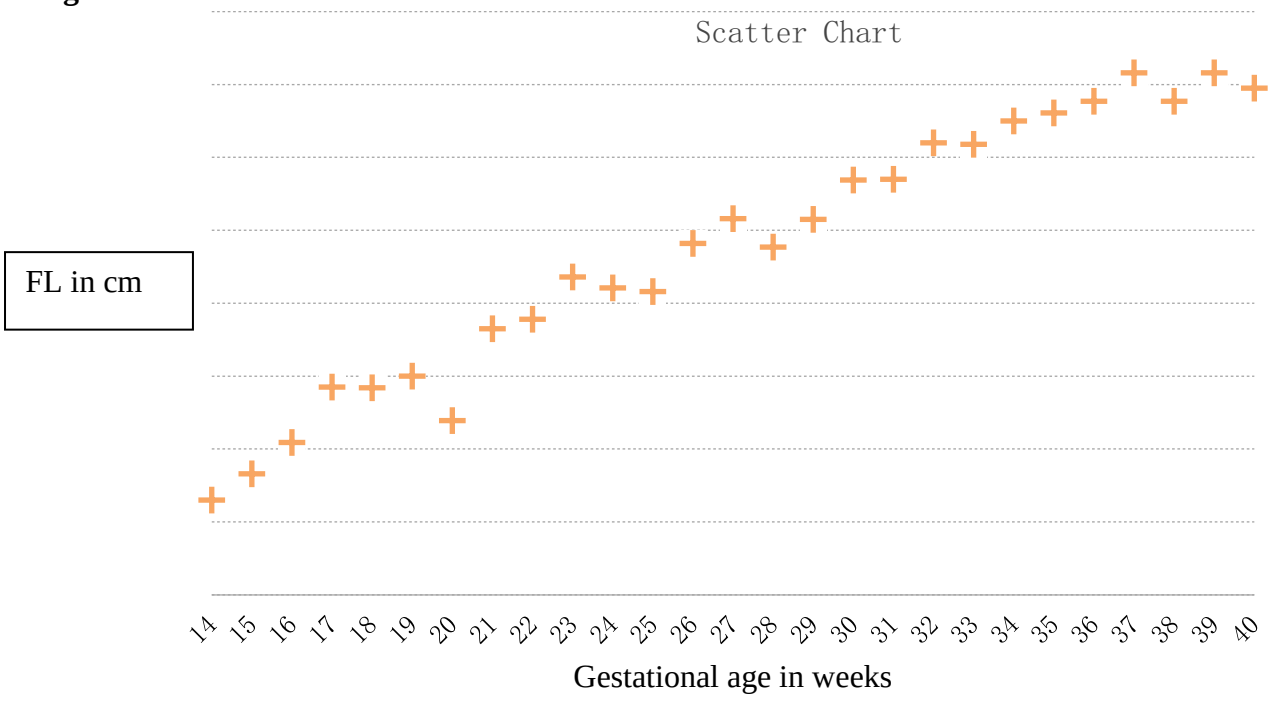

Table-7: Mean Transverse Cerebellar Diameter during Different GA

S.No	Period Of G.A (wks)	No. of Cases	Mean TCD
1	14-20	34	17.77mm
2	21-30	76	28.40mm
3	31-40	76	40.00mm

Table 8: Cerebellar Measurements during Different Gestation Ages

S.No	Gestation Age(wks)	TCD (Min)	TCD (Max)
1	14-20wks	1.27cm	2.6cm
2	21-30wks	2.1cm	3.85cm
3	31-40	3.2cm	5.8cm

Table 9: Transcerebellar Diameter Vs Gestational Age: Pearson correlation coefficient (R) =0.878, Coefficient Of Determination (R^2) =0.771 P Value <0.00001

Gestational Age (Weeks)	Cerebellar Diameter (CM)	Standard Deviation in CM
14	1.27	0
15	1.44	0 .19
16	1.61	0 .09
17	1.85	0 .08
18	2.01	0 .11
19	1.94	0
20	1.72	0 .37
21	2.10	0 .23
22	2.55	0 .12
23	2.62	0 .41
24	2.44	0 .19
25	2.54	0 .28
26	2.90	0 .39
27	2.87	0 .42
28	3.02	0 .21
29	3.20	0 .33
30	3.37	0 .23
31	2.99	0 . 68
32	3.78	0 .32
33	3.90	0 .62
34	3.86	0 .63
35	4.40	0 .61
36	3.98	0 .44
37	4.01	0 .46
38	4.16	0 .17
39	3.45	0 .51
40	3.90	0 .23

There is a linear relationship seen between gestational age & TCD, shown in the scatter diagram

Fig-5

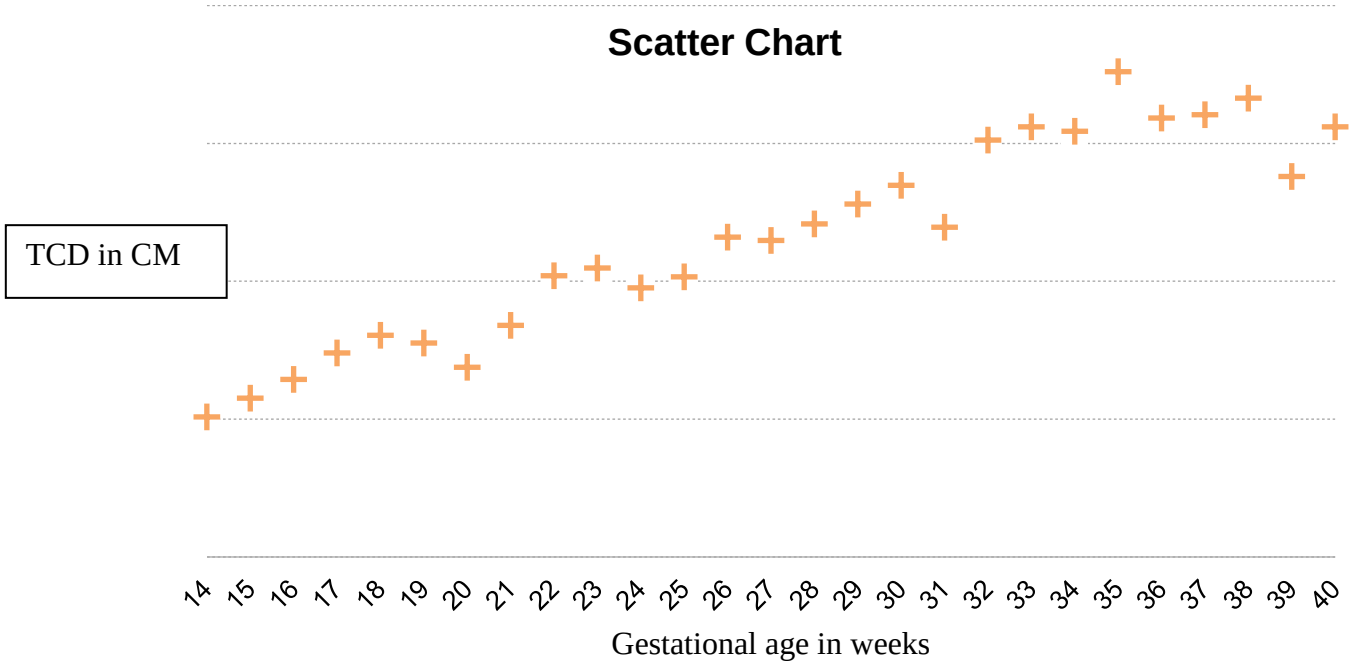

Table 10: Ratio of Transcerebellar Diameter to Abdominal Circumference

Gestational Age in Weeks	Ratio of TCD and AC
14	0.17
15	0.16
16	0.16
17	0.14
18	0.15
19	0.15
20	0.14
21	0.13
22	0.14
23	0.13
24	0.13
25	0.13
26	0.13
27	0.13
28	0.13
29	0.14
30	0.14
31	0.11
32	0.14
33	0.13
34	0.13
35	0.15
36	0.13
37	0.13
38	0.13
39	0.11
40	0.12

Discussion

In this study, a total of 186 normal pregnancies with aged between 18-38 years were included. Mean age was 27.3 years. Majority of patients were in the age group 26-35 years. (Table-1) Similar age distribution was found in the study conducted in 2008 by Mac Gregor et al. As far as parity is concerned, majority were the mothers of one child before present pregnancy, followed closely by primigravid mother. Only one patient was mother of three children. (Table-2) Sabagha and Globb et al had similar distribution according to parity. We first correlated biparietal diameter with gestational age using the pearson correlation. Biparietal diameter appeared to increase in a linear relation with gestational age and a strong correlation was found. (Table-3)

Pearson correlation coefficient, R value was calculated using the formula as below:

$r = \sum ((X-My)(Y-Mx))/\sqrt{((SSx)(SSy))}$

where X is the gestational age

Mx is the mean gestational age.

Y is the biparietal diameter

My is the mean biparietal diameter

SSx is the sum of square of standard deviations in gestational age SSy is the sum of square of standard deviations in biparietal diameter Pearson correlation coefficient (R) came out to be 0.949 with a determination coefficient (R^2) of 0.901 and the test was significant with a p value of <0.00001In correlation with Head circumferential (HC) (Table-4), we found a correlation coefficient (R) of 0.943 with a determination coefficient (R^2) 0.890 while Abdominal circumference (AC) (Table-5) steadily increased with gestational age in linear progression with correlation coefficient (R) of 0.948 and a determination coefficient (R^2) of 0.899. Finally Femur length (FL)(Table-6) also correlated well with the gestational age with a correlation coefficient of 0.949. The mean BPD, FL,HC and AC measurements at various gestations observed in our study were similar to measurements obtained by previous authors O'Brien et al[8] and Kaul et al.[9]

As per ultrasound literature Transcerebellar diameter (TCD) is an unique, reliable parameter for estimating the duration of gestation and is consistently superior in predicting GA in both singleton and twin gestation.[10,11,12,13]

Measurement of the transverse cerebellar diameter can be done on most of the foetuses, irrespective of the fetal head shape. Sonographic visualization of cerebellum can be done as early as 12-13 weeks of gestation. The cerebellum appears as two lobules on either side of the midline, located in posterior cranial fossa. During 14th to 20th week of gestation, TCD in millimetres is equivalent to the gestation age in weeks. After 20 weeks, However the TCD in millimetres exceeds gestational age in weeks. The mean transverse cerebellar diameter (TCD) was 17.77mm at 14-20 weeks, 28.40mm at 21-30 weeks and 40.00mm at 31-40 weeks. (Table-7) At 14-20 weeks of gestational age, the minimum TCD was 1.27cm and maximum TCD was 2.6 cm, at 21-30 weeks of gestation ,it was 2.1 cm and 3.85 cm and at 31-40 weeks, it was 3.2 cm and 5.8 cm respectively. (Table 8) When individual observation of mean transverse cerebellar diameter was studied in relation to period of gestation in weeks (Table-9),the correlation coefficient was found to be 0.878, which was statistically significant (p <0.00001), similar to the findings of Meyer WJ et al[14], Goel P.et al[15]. There is a linear relationship between cerebellar growths as compared to transverse cerebellar diameter. Fetal abdominal circumference (AC) is one of the important fetal parameters to be affected early in the process of impaired fetal growth. Hence a ratio between the TCD and AC was calculated after each examination. The ratio remained constant during gestation (Table- 10). The mean ratio was 13.6%. The median ratio was 14.0%.7Pilu et al[16] investigated the ultrasonography of the posterior fossa of the fetus and confirmed the capability of ultrasound to demonstrate the anatomy of the posterior fossa. They suggested that the fetal transcerebellar diameter in utero between 17 and 40 weeks of gestation is more useful indication of

accurate gestational age, particularly in case of dolichocephaly and brachycephaly and also facilitates the antenatal detection of congenital disorders.

Mikovic et al[17] studies the growth of cerebellum in normal pregnant women and stated that TCD may be practically applied in the gestational age measurement particularly in cases where it is difficult or impossible to measure BPD and in cases where it is unstable due to head moulding, since the cerebellum is not liable to changes particularly inform.

William.J. Meyer et al prospectively evaluated the accuracy of a gestational age independent method of detecting abnormal growth by transverse cerebellar diameter/abdominal circumference ratio and compared this with standard ultrasonographic methods of growth assessment. They concluded that TCD/AC ratio is an accurate gestational age independent method of identifying the small for gestational age but not the large for gestational age infant.[18] Malik R,Pandya VK et al[19] in 2006 concluded that TCD showed 92% predictive accuracy for gestational age as compared to the standard nomogram by chitty et al.In this study the TCD/AC ratio was found to be 0.14064±0.059 (SD) which remained fairly constant throughout pregnancy and thus it is a useful gestational age independent parameter. Malik G, Waqar F et al[20] in 2003 reported that transeverse cerebellar diameter varied in a linear fashion in third trimester, while transeverse cerebellar diameter/ abdominal circumference (TCD/AC) ratio remained constant in second half of pregnancy. All the parameters were expressed by regression equations and correlation coefficients were found to be statistically significant (r=0.99 for TCD, r=0.98 for TCD/AC all $p < 0.0001$).

Conclusion

Fetal biparietal diameter, femur length, abdominal circumference and head circumference measurements of the fetus in normal pregnancies were comparable with transcerebellar diameter measurement between 15 and 40 weeks of gestation. Estimation of gestational age by transcerebellar diameter correlated with the estimation of gestational age by other multiple growth parameters. Transcerebellar diameter is the better parameter for gestational age assessment than BPD and FL as it is not fraught with the problems in the measurements commonly encountered in BPD and FL due to its easily identifiable landmarks. The transcerebellar diameter should be a routine measurement not only for the estimation of gestational age,but failure to demonstrate the cerebellum could be a sign of Arnold-Chiari malformation or Dandy Walker cyst as studied by Mcleary et al.

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