Evaluation of Gestational Age by Using Fetal Biparietal Diameter in Second and Third Trimester on Ultrasonography

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Abstract

Biparietal diameter (BPD) is one of the basic biometric parameters used to assess *fetal* size. BPD together with head circumference (HC), abdominal circumference (AC), and femur length (FL) are computed to produce an estimate of *fetal* weight. After 13 weeks of gestation, the *fetal* age may be estimated using the *biparietal diameter* (the transverse *diameter* of the head, across the two parietal bones), the head circumference, the length of the femur, the crown-heel length (head to heel), and other *fetal* parameters. The biparietal diameter (BPD) is among the most accurate 2nd trimester measures of gestational age. Measured from the beginning of the fetal skull to the inside aspect of the distal fetal skull ("outer to inner") at the level of the cavum septum pellucidum, this is one of the basic fetal measurements. Gestational age is usually determined by the date of the woman's last menstrual period, and assuming ovulation occurred on day fourteen of the menstrual cycle. Sometimes a woman may be uncertain of the date of her last menstrual period, or there may be reason to suspect ovulation occurred significantly earlier or later than the fourteenth day of her cycle. Ultrasound scans offer an alternative method of estimating gestational age. The most accurate measurement for dating is the crown-rump length of the fetus, which can be done between 7 and 13 weeks of gestation. After 13 weeks of gestation, the fetal age may be estimated using the biparietal diameter (the transverse diameter of the head, across the two parietal bones), the head circumference, the length of the femur, the crown-heel length (head to heel), and other fetal parameters [1]. In the present study week wise measurement of fetal biparietal diameter was taken in 282 women in second & third trimester. Then week wise mean values and standard deviation of fetal Biparietal Diameter were calculated. Simple linear regression analysis of the observations was done for estimating gestational age from the measurements of Biparietal Diameter, for total number of cases, in second and in third trimester separately. The regression equations derived for Biparietal Diameter for estimating gestational age in a normally developing fetus increase with gestational age & showed good correlation with gestational age.

Keywords: Biparietal Diameter; Second Trimester; Third Trimester; Fetal Growth; Gestational Age; Ultrasound Scan.

Introduction

Human development is continuous process that begins when an oocyte from female is fertilized by a sperm. Cell division, programmed cell death, differentiation, growth and cell rearrangement transform the fertilized oocyte into a multicellular adult human being. The most developmental changes occur during the embryonic and early fetal periods. The human development is divided into prenatal and postnatal period. There are many changes that occur from the 3rd to 8th week (calculated from the date of fertilization) called as embryonic development. Changes occur from 9th week to birth are meaningful because they signify that the embryo has developed into a recognizable human being called a fetus [2].

Gestational age is age of unborn baby, defined in

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weeks as beginning from first day of last menstrual period prior to conception. Trimester is period of three calendar months during a pregnancy. Clinically, the gestational period is divided into three trimesters. Estimation of gestational age and thereby forecasting expected date of delivery (EDD) is not only concern of the Individual but it is invaluable in the diagnosis of intrauterine growth retardation of fetus and obstetric planning. But significant number of females (20-30%) either fail to remember LMP or report inaccurately. The matter becomes complicated when conception occurs during lactational amenorrhoea or soon following withdrawal of contraceptive pills in which ovulation may be delayed for 4-6 weeks or in cases with bleeding in early part of pregnancy. The parameters either singly or in combination useful in predicting the gestational age with fair degree of accuracy are Naegeles formula, Date of quickening, Palpation of fetal parts and Auscultation of fetal heart sound [3].

The methods like physical examination, menstrual history, laboratory methods have limitations in assessing fetal maturity, development and well being. At the same time Roentgenography like procedures having hazards of invasive procedure or radiation compelled the research of safer, non-invasive and reliably predictive investigation modality, it was brought forth in the form of ultrasonography. Added advantage of it being evaluation of multiple parameters in the same readings. Ultrasonography is non-ionising, non-invasive, safe and accurate method of objectively evaluating the fetal growth in utero.

The ultrasound waves can be defined as sound waves whose frequency is far higher than those waves which can be registered by the human ear. Ultrasound is high frequency sound waves over 20,000 cycles per second (20 KHz). These waves are originated from a transducer & travel through human tissues at a velocity of 1500 meter per second, reflected ultrasound pulse is detected by transducer and amplified in the scanner [4,5].

Correct assessment of gestational age is a cornerstone of management of any obstetric case. Various measurement and external characteristics are useful for estimating fetal age. Crown rump length is the method of choice for estimating fetal age until the end of the first trimester because there is very little variability in fetal size during this period. In second and third trimester, fetus grows sufficiently in size, several structures can be identified and measured ultrasonographically, but the basic measurements are Biparietal Diameter, Head circumference, Abdominal Circumference and Femur length. In the present study

measurements of Biparietal Diameter in second & third trimester are taken into consideration.

Accurate knowledge of gestational age is a keystone in the obstetrical ability to successfully manage the antepartum care of the patient and is critically important in the interpretation of antenatal test and successful planning of appropriate therapy and interventions.

Aims and Objectives

The study "Evaluation of gestational age by using fetal Biparietal diameter in second and third trimester on ultrasonography" was undertaken with the following Aims and Objectives.

Aim

• To record Bi-parietal Diameter, and to estimate gestational age in second & third trimester.

• To derive regression formula for Bi-parietal Diameter used to calculate accurate gestational age.

Objectives

1. To assess fetal growth.

2. To determine Bi-parietal Diameter as a sensitive parameter for second & third trimester.

3. To compare the results of present study with previous studies.

4. To observe mean growth rate pattern of the fetus.

Materials and Methods

The study "Evaluation of gestational age by using fetal Biparietal diameter in second and third trimester on Ultrasonography" was carried out in our Medical College and Hospital, over the period of July 2011 to July 2013. The study included 282 pregnant women. Who were selected on the following basis.

The subjects were females attending ANC clinic for ultrasonography screening at Medical College and Hospital. Subjects of the study mainly include urban as well as rural areas in the vicinity.

Inclusion Criteria

i. Women with known LMP

ii. Women with regular menstrual cycle

iii. Women with singleton pregnancy

iv.   Women having age between 18-34 yrs

v.   Women with uncomplicated pregnancy

Exclusion Criteria

i.   Women with multiple pregnancies

ii.   Women with irregular menstrual cycles

iii. Women having diabetes mellitus

iv.   Women with diseases like hypertension, chronic renal disease, heart diseases, iron deficiency anaemia.

v.   Women having Fetus with congenital anomalies.

The study was carried out on 282 pregnant women. The subjects were informed regarding the nature and purpose of the study. For collection of the data proper permission was obtained from ethical committee and radiology department. The subjects were given prior appointment in morning hours and screened under guidance of sonologist throughout the study.

1.   In this study various particulars of the subjects like age, menstrual and obstetric history had been recorded in the Proforma.

2.   The routinely used Ultrasonography Machine in the obstetric practice, i.e Sequina L&T with 3-5 MHz macro convex probe was used.

3.   Subject was asked to lie in supine position on the ultrasound screening table with her abdomen exposed. To ensure an airless contact between the tissue and the transducer probe Sonogel, a mineral jelly was applied all over the abdominal surface.

4.   The fetal position was assessed on sonographic examination with full bladder, by placing the transducer probe in longitudinal direction and moving it all over the surface of the abdomen.

5.   The American Institute of Ultrasound in Medicine recommendations were used for measurements of all the fetal parameters [6].

The Biparietal Diameter (BPD) was measured in the transaxial plane at the widest portion of the skull, at the level of the thalami and cavum septi pellucidi. The cerebellar hemispheres should not be visible in this scanning plane. The measurement is taken from the outer edge of the proximal skull to the inner edge of the distal skull.

The data so collected from 282 subjects was then subjected to statistical analysis by expert statistician with the help of SYSTAT Crainsoft version 12 software. Standard statistical methods, parametric methods were used for the evaluation and significance.
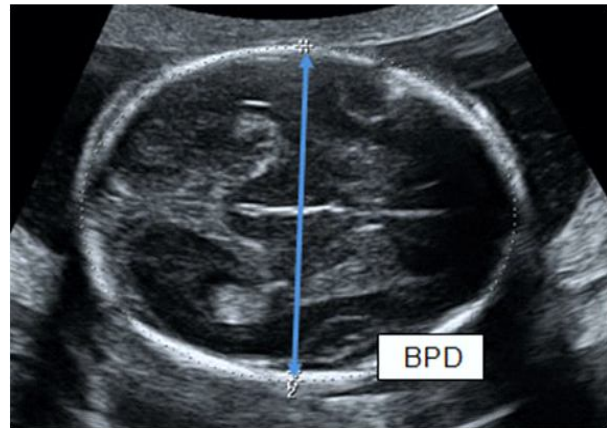
Photograph 1: Showing ultrasonographic image of Fetal Biparietal Diameter

Results

The study of "Evaluation of gestational age by using fetal Biparietal diameter in second and third trimester on Ultrasonography" was carried out in Medical College & Hospital on a total of 282 subjects.

The data collected was formulated according to the menstrual weeks from 13 to 42 weeks. All the observations of the fetal biparietal diameter were taken in centimeters.

Standard deviation of Biparietal diameter for each week was calculated. Similarly the statistical mean of each parameter for each week was calculated. The weeks of gestation were defined as completed week. For e.g. 13th week refers to 13.00 to 13.86 weeks of menstrual age. 7 days = 1week, hence 1day = 0.14 weeks. Like this subsequently for each day.

The observations of week wise mean values and standard deviation of fetal Biparietal Diameter are shown in Table 1. Biparietal Diameter by Ultrasonography was measured in a total of 282 subjects.

Simple Linear Regression

Simple linear regression analysis of the observations was done for estimating gestational age from the measurements of Biparietal Diameter, for total number of cases, in second and in third trimester separately.

Simple Linear Regression for the Observations

Regression output for total cases (13 to 42 weeks)

Constant   =   2.98

Standard error of Y ests   =   0.1085

Coefficient of determination (R) = 0.9683

No. of observations = 282

Degree of freedom = 280

X coefficients = 3.81

Regression equation:-

G.A. = 2.98 + 3.81 x BPD

From the above equation it is clear that, for every 1cm increase in BPD, the gestational age (G.A) increases by 3.81 weeks.

As the value of R is 0.9683 the variation in fetal growth on the basis of Biparietal Diameter during 13 to 42 weeks can be explained to the extent of 96.83%.

The value of R is highly significant (Student's 't' test value =214.99, p<0.0001, very highly significant) showing that there is *statistically highly positive or strong positive association between gestational age and Biparietal Diameter.*

Tabke 1: Mean and Standard Deviations of Fetal Biparietal Diameter (Weekwise)

Menstrual age in weeks	No. of Cases	Mean	Standard Deviation
13	8	2.37	0.44
14	11	2.88	0.40
15	10	3.34	0.24
16	7	3.40	0.37
17	12	3.72	0.14
18	9	4.15	0.13
19	7	4.66	0.28
20	11	4.85	0.29
21	10	5.11	0.36
22	12	5.27	0.59
23	10	5.53	0.41
24	10	5.68	0.38
25	8	6.45	0.35
26	12	6.10	0.52
27	4	7.15	0.50
28	9	6.97	0.44
29	10	7.30	0.29
30	9	7.19	0.52
31	11	7.94	0.34
32	12	7.64	0.45
33	14	7.94	0.4
34	13	8.25	0.59
35	8	8.50	0.31
36	13	8.56	0.52
37	10	8.98	0.21
38	14	8.94	0.33
39	8	9.04	0.41
40	6	9.02	0.78
41	2	8.15	0.21
42	2	8.55	0.07
TOTAL	**282**		
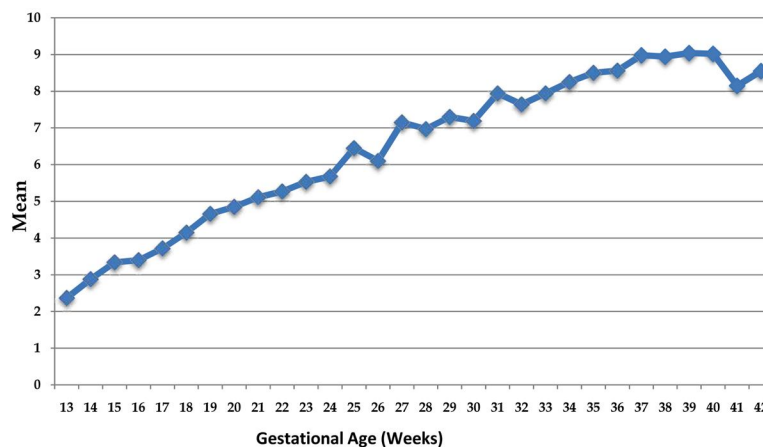
Graph 1: Showing graphical representation of the above data**.** (Week wise average values of fetal Biparietal Diameter)
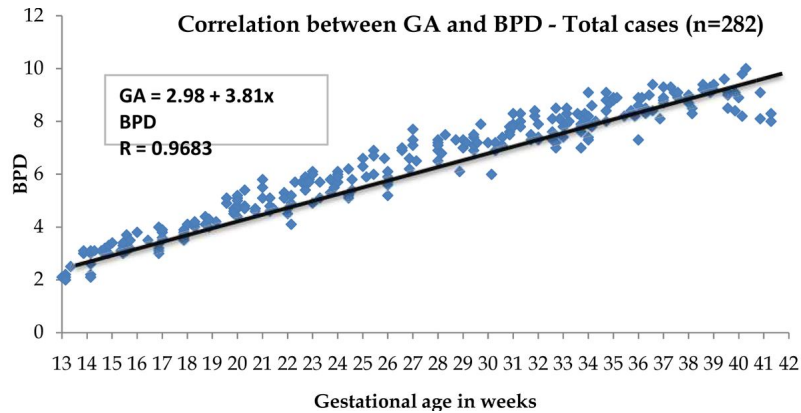
Graph 2: Showing linear correlation between the fetal Biparietal Diameter and gestational ages in total 282 cases
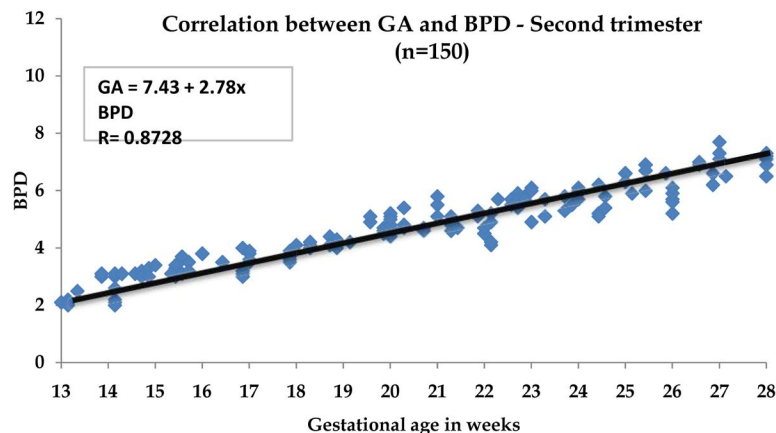
Regression output for 2nd trimester (13 to 28 weeks)

Constant	=	7.43
Standard error of Y ests	=	0.1430
Coefficient of determination (R) =		0.8728
No. of observations	=	150
Degree of freedom	=	148
X coefficients	=	2.78

Regression equation:-

G.A. = 7.43 + 2.78 x BPD

From the above equation it is clear that during the second trimester, for every 1cm increase in BPD, the gestational age (G.A) increases by 2.78 weeks. As the value of R is 0.8728, the variation in fetal growth on the basis of Biparietal Diameter during second trimester can be explained to the extent of 87.28%. The value of R is highly significant (Student's 't' test value =118.46, $p < 0.0001$, very highly significant) showing that there is statistically highly positive or strong positive association between Gestational age and Biparietal Diameter.

Graphs 3: Showing linear correlation between Gestational age and Biparietal Diameter in second trimester (n=150)

Regression output for 3rd trimester (29 to 42 weeks)

|		
Constant	=	5.99
Standard error of Y tests	=	0.4402
Coefficient of determination (R) =		0.7501
No. of observations	=	132
Degree of freedom	=	130
X coefficients	=	3.50

Regression equation:

G.A = 5.99 + 3.50 x BPD

From the above equation it is clear that during the third trimester, for every 1 cm increase in BPD, the gestational age (G.A) increases by 3.50 weeks. As the value of R is 0.7501, the variation in fetal growth on the basis of Biparietal Diameter during third trimester can be explained to the extent of 75%.

The value of R is highly significant (Student's 't' test value =173.0, p<0.0001, very highly significant) showing that there is *statistically highly positive or* *strong positive association between gestational age and Biparietal Diameter.*

Correlation between GA and BPD - Third trimester (n=132)

GA = 5.99 + 3.50 x BPD
R = 0.7501
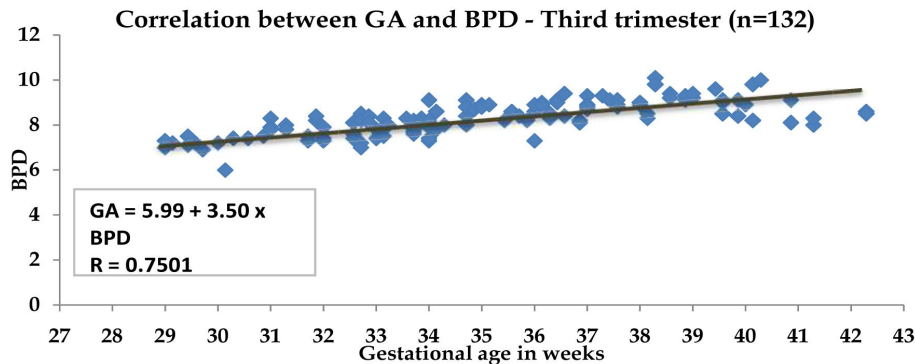
Graphs 4: Showing linear correlation between Gestational age and Biparietal Diameter in third trimester (n=132)

Discussion

Ultrasonography is primary imaging modality in the evaluation of fetus because of its wide availability, low cost, and lack of adverse effects. The chorionic sac and its contents may be visualized by ultrasonography during the embryonic and fetal periods. Placental and fetal size, multiple fetuses, abnormalities of placental shape, and abnormal presentations can also be determined. Ultrasound scans give accurate measurements of the Biparietal Diameter of the fetal cranium, from which close estimates of fetal age and length can be made. Ultrasound examinations are also helpful for diagnosing abnormal pregnancies at a very early stage. Rapid advances in ultrasonography have made this technique a major tool for prenatal diagnosis of fetal abnormalities. Thus ultrasonography is a most reliable check on the growth of the fetus [2].

The fourth to eight weeks of development constitutes most of the embryonic period; however, critical developmental events also occur during first three weeks, such as a cleavage of zygote, blastogenesis, and early development of nervous and cardiovascular systems. All major external and internal structures are established during fourth to eighth weeks. By the end of this organogenetic period, the main organ systems have begun to develop, however the function of most of them is minimal, except for the cardiovascular system. As the tissue and the organs form, the shape of embryo changes and by the eighth week it has distinctly human appearance. Early in ninth week, legs are short and thighs are relatively small. By the end of 12 weeks, the upper limbs have almost reached their final relative lengths, but the lower limbs are still not so well developed and are slightly shorter than their final relative lengths. By the end of 12 weeks, primary ossification centers appear in the skeleton, especially in the cranium (skull) and long bones. By the 16 weeks the head is relatively small compared with that of the 12-week fetus and the lower limbs have lengthened. Ossification of the fetal skeleton is active during this period, and the bones are clearly visible on ultrasound images. In first trimester of pregnancy, the gestational sac size and the crown rump length measurements have been reported as primary means of evaluating the gestational age. Fetal head, body and extremity measurements have been widely reported and found to be used in second and third trimester [2].

The differentiation between hard and soft tissues of the embryo is possible after about 10th week of gestation when other parameters like Biparietal Diameter, Head circumference, Abdominal circumference, length of long bones can be measured and become more important than the crown rump length. Measurements of fetal parts during routine ultrasonography screening have been recommended [7].

The study of measuring fetal parts started as early as 1918 with the help of aborted specimens of human fetuses. With advancement in technologies, ultrasonographic technique was used for this purpose. Amongst these investigators were Hadlock[8] (1982), Yeh Ming [9] (1982), Merz [10] (1987) etc.

Studies by Indian authors Vaidya [15] (1986), Khandeparkar [11] (1986), Ghamande [12] (1989), Rajan R [13] (1991) were reflection of the fetal growth parameters in a particular region of India. India being a multi racial country, regional differences in the growth pattern of fetal parameters is expected.

The present study is a cross sectional analysis of

fetal Biparietal diameter in 282 subjects was conducted considering the above views. Transabdominal sonography of these subjects was performed and the measurements of fetal Biparietal diameter was recorded in a proforma and subjected to statistical analysis.

The mean values of the fetal Biparietal diameter

for each week, so obtained were compared with those of the previous studies as follows:

The Table 2 Shows the week wise averages of the measurements of the Biparietal Diameter as studied by Sabbagha RE [14] 41978), Merz E [10] (1987) and Rajan et al [13] (1991) compared with those calculated in the present study. The present study correlates with

Table 2: Showing comparison between week wise mean of the measurements of Biparietal Diameter

Gestational Age In Weeks	Sabbagha (1978)	Rajan (1991)	Merze (1987)	Present Study
13	-	2.3	2.3	2.37
14	2.8	2.7	2.7	2.88
15	3.2	3	3	3.44
16	3.6	3.3	3.3	3.4
17	3.9	3.7	3.7	3.72
18	4.2	4	4.2	4.15
19	4.5	4.3	4.4	4.66
20	4.8	4.6	4.7	4.85
21	5.1	4.9	5	5.11
22	5.4	5.1	5.5	5.27
23	5.8	5.4	5.8	5.53
24	6.1	5.7	6.1	5.68
25	6.4	6.1	6.4	6.45
26	6.7	6.5	6.8	6.1
27	7	6.7	7	7.15
28	7.2	7	7.3	6.97
29	7.5	7.2	7.6	7.3
30	7.8	7.4	7.7	7.19
31	8	7.7	8.2	7.94
32	8.2	7.9	8.5	7.64
33	8.5	8	8.6	7.94
34	8.7	8.1	8.9	8.25
35	8.8	8.3	8.9	8.5
36	9	8.5	9.1	8.56
37	9.2	8.6	9.3	8.98
38	9.3	8.7	9.5	8.94
39	9.4	8.8	9.5	9.04
40	9.5	9	9.9	9.02
41	-	-	9.7	8.15
42	-	-	10	8.55

Table 3: Table showing comparison between week wise mean of the measurements of *Biparietal Diameter*

Gestational age in weeks	Vaidya (1985)	Composite Mean (Sabbagha et al)	Present study
25	6.8	6.4	6.24
26	7.0	6.7	6.1
28	7.7	7.2	6.97
30	8.2	7.8	7.19
32	8.4	8.2	7.94
34	8.5	8.7	8.25
36	8.8	8.9	8.56
38	9.2	9.3	8.94
40	9.4	9.5	9.02
42	9.2	-	8.55

the above studies.

Table 3 shows the week wise mean of measurements of Biparietal Diameter studied by **V**aidya [15] (1985) and composite table mean is derived by Sabbagha from mean diameters of four series studied by Sabbagha et al (1976), Campbell and

Newman (1971), Levi & Smets and Verma from 25 to 42 weeks gestational age compared with those calculated in present study. The present study correlates with the above studies.

The regression equations for the Biparietal Diameter derived in the present study are as follows:

BPD	2nd Trimester	3rd Trimester
	G.A. = 7.43 + 2.78 x BPD	G.A = 5.99 + 3.50 x BPD

The previous investigators have studied equations for estimation of gestational age from the measurements of Biparietal Diameter. These equations could not be compared with the equations derived in the present study because of difference in statistical method.

Summary and Conclusions

The study "Evaluation of gestational age by using fetal Biparietal diameter in second and third trimester on Ultrasonography" by taking into consideration fetal Biparietal Diameter was recorded. This cross-sectional study was carried out on 282 ANC women with age group 18-34 yrs. This study was carried out during the period July 2011 to July 2013 in Medical College and Hospital.

All the subjects had sound knowledge about their menstrual dates. Data was collected from these subjects with regards to fetal Biparietal Diameter and recorded in the proforma.

The data so collected was tabulated according to the menstrual weeks from 13 to 42 weeks. The statistical mean and standard deviation of each parameter for each week was calculated with statistical software SYSTAT version 12. (CRAIN SOFT)

The weeks of gestation were defined as completed week. For example 13th week refers to 13.00 to 13.86 weeks of menstrual age.

Comparison of week wise mean value for fetal Biparietal Diameter was done with studies done previously and represented in a tabular form & graphical representation of the results was done.

Finally, sonographically measured Biparietal Diameter during second and third trimesters of pregnancy were subjected to statistical analysis by simple linear regression. The regression was done for each week.

1. The Biparietal Diameter is found to be statistically highly significant.

2. Following are the regression equations for the Biparietal Diameter for total number of cases, for second trimester and third trimester.

Regression Equation for BPD.

Parameter	Regression Equation for Total Number of Cases	Regression Equation for 2rd Trimester	Regression Equation for 3rd Trimester
BPD	G.A. = 2.98 + 3.81 x BPD	G.A. = 7.43 + 2.78 x BPD	G.A = 5.99 + 3.50 x BPD

3. The regression equations derived for Biparietal Diameter for estimating gestational age in a normally developing fetus increase with gestational age & showed good correlation with gestational age.

4. The regression equations derived for second and third trimesters for Biparietal Diameter can be used for estimating gestational age/ fetal growth in women with uncertain menstrual dates.

5. Assessment of gestational age helped in calculating the EDD (expected date of delivery) in all patients, thus improving the antepartum management.

6. Gestational ages are fairly accurate predictors of fetal growth.

7. The regression equations derived for second and third trimesters for Biparietal Diameter can be used for conforming gestational age/fetal growth in women with known menstrual dates.

8. Results of present study are comparable with previous studies

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