ejpmr, 2018,5(4), 393-398

SJIF Impact Factor 4.897

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

ULTRASONOGRAPHIC MEASUREMENT OF TRANSVERSE CEREBELLAR DIAMETER (TCD) IN ASSESSMENT OF GESTATIONAL AGE COMPARED TO FEMORAL LENGTH (FL) AND BIPARIETAL DIAMETER (BPD)

Dr. Rehana Afshan[1], Dr. Sabeeha Gul*[2] and Dr. Mir Saiqa Shafi[3]

[1,2,3]Senior Resident, MD(Radiodiagnosis), Department of Radiology, Government Medical College Srinagar, Jammu and Kashmir, 190010, India.

***Corresponding Author: Dr. Sabeeha Gul**

Senior Resident, MD(Radiodiagnosis), Department of Radiology, Government Medical College Srinagar, Jammu and Kashmir, 190010, India.

Article Received on 02/02/2018 **Article Revised on 23/02/2018** **Article Accepted on 15/03/2018**

ABSTRACT

Background: The study was done on pregnant women of gestational age of 16 weeks onwards. Routine antenatal USG scan included FL, BPD, AC, HC was used for estimation of gestational age with exception as in fetuses suffering from skeletal dysplasia or IUGR, which will have deformed appendicular skeleton. In those fetuses estimation of gestational age is not possible by FL, BPD hence TCD was measured. A strong correlation between gestational age estimated by gold standard (FL, BPD) and gestational age estimated by TCD was found. **Aim:** The study was conducted to measure the transverse cerebellar diameter (TCD) and compare it with femoral length (FL) and Biparietal diameter (BPD) in assessment of Gestational age, done on pregnant women of gestational age of 16 weeks onwards. **Methods:** We performed a cross sectional study done on 60 pregnant women with normal pregnancy, of normal singleton fetuses, 16 weeks onwards. The statistical method was of regression analysis and It was particularly useful in generating growth and dating curves for various foetal parameters. Differences in the estimation of BPD, TCD, and FL, TCD in prediction of gestational age were compared. At each given gestational age, the measurements were assessed. The difference between estimated measurements at each gestational age versus that of Hadlock was performed. Gestational age was estimated using FL and BPD. Then gestational age was estimated by TCD. All the three gestational age's were compared separately. Gestational age derived from FL and TCD, gestational age derived from BPD and TCD. Statistical analysis revealed strong correlation between gestational age estimated by gold standard (FL,BPD) and gestational age estimated by TCD. **Results**: In every patient first Gestational age was calculated by measuring using femur length and biparietal diameter of foetus and then a Gestational age (gold standard method) was calculated by measuring the transverse cerebellar diameter of foetus. (experimental method) in order to determine whether these two methods can be used interchangeably or the new method can replace the established one and the bland altman graph was plotted. At the end the correlation was found out to be significant. **Conclusion:** TCD is a reliable parameter in estimation of Gestational age, and can be used alternatively in fetuses with IUGR or skeletal dysplasia where FL and BPD cannot give correct Gestational Age.

KEYWORDS: TCD, Gestational age, IUGR, Skeletal dysplasia, FL, BPD.

INTRODUCTION

When choosing the optimal parameter for estimating Gestational age, it is essential that the structure has little biologic variation, and can be measured with a high degree of reproducibility (Campbell 1993).[1] In the past, the Biparietal diameter (BPD) had been described as a reliable method of determining Gestational age (Campbell 1969; Kurtz et al., 1980).[2,3] While the BPD was the first foetal parameter to be clinically utilized in the determination of foetal age in the second trimester, more recent studies have evaluated the use several other biometric parameters including head circumference (HC), abdominal circumference (AC), femur length (FL), foot length, ear size, orbital diameters, cerebellum diameter and others (Hadlock et al., 1982; O'Brien 1981; Mercer et al., 1987;).[4,5,6] In a large study by Chervenak et al, (1998) that evaluated pregnancies conceived by in vitro fertilization and thus had known conception dates, head circumference was found to be the best predictor of Gestational age compared with other commonly used parameters.[7] This finding is in agreement with that of Hadlock 1984 and Benson 1991 who compared the performance of HC, BPD, FL and AC in different populations[8,9]

The foetal head circumference should be measured sonographically in a plane that is perpendicular to the parietal bones and traverses the third ventricle and thalami (Filly & Hadlock 2000).[10] The image should demonstrate smooth and symmetrical calvaria and the presence of a cavum septum pellucidum. The callipers should be placed on the outer edges of the calvaria and a computer-generated ellipse should be adjusted to fit around the foetal head without including the scalp. The Biparietal diameter can be taken in the same plane by placing the callipers on the outer edge of the proximal calvarium wall and on the inner edge of the distal calvarium wall (Manning 1999).[11] The BPD, while highly correlated with HC, is less accurate as a predictor of Gestational age as a result of variation in head shape (Chervenak et al., 1998).[7] Using multiple parameters, the accuracy of Gestational age assessment can be improved (Chervenak et al., 1998).[7] Along with head circumference, the addition of one parameter (AC or FL) or two parameters (AC and FL) is slightly superior to head circumference alone in the assessment of foetal age. The use of multiple parameters also reduces the effect of outliers caused by biologic phenomena (i.e. congenital anomalies or growth variation) or technical error in measurement of a single structure. Still, with multiple parameters, it is essential to take the images in the proper plane and place the callipers appropriately. For example, when assessing FL, the long axis of the femur should be aligned with the transducer measuring only the osseous portions of the diaphysis and metaphysis of the proximal femur. While not included in the FL measurement, the proximal epiphyseal cartilage (future greater trochanter) and the distal femoral epiphyseal cartilage (future distal femoral condyle) should be visualized to assure that the entire osseous femur can be measured without foreshortening or elon Gestational agetion (Filly & Hadlock 2000; Goldstein 1987).[10,12] Similarly, the AC must be measured appropriately in order to obtain an accurate estimate. The image should be taken in a plane slightly superior to the umbilicus at the greatest transverse abdominal diameter, with the liver, stomach, spleen and junction of the right and left portal veins visualized (Filly & Hadlock 2000).[10]

Modern ultrasound machines are equipped with computer software that will automatically calculate the estimated Gestational age based on the entered measurements. Using a large singleton in vitro fertilization (IVF) population from 14-22 weeks, Chervenak et al., (1998) derived an optimal Gestational age prediction formula using stepwise linear regression with a standard deviation (SD) of 3.5 days between the predicted and true Gestational.[7] This formula was compared it to 38 previously published equations. Nearly all equations produced a prediction within one week demonstrating that foetal biometry in the mid trimester for assessment of Gestational age is applicable and accurate across populations and institutions. Clinically, when a discrepancy greater than seven days (2SD) exists between the menstrual and ultrasound dating in the second trimester, the biometric prediction should be given preference.

In addition, we published a study evaluating and comparing the accuracy of first- and second-trimester ultrasound assessment of Gestational age using pregnancies conceived with in vitro fertilization (Kalish et al., 2004).[13] Our data showed that first- and second-trimester estimates of Gestational age had small differences in the systematic and random error components for an estimated Gestational age that was based on foetal crown-rump length or biometry. On the basis of this data derived from pregnancies with known conception dates, ultrasound scanning can determine foetal age to within <5 days in the first trimester and <7 days in the second trimester in >95% of cases. This data further confirms the findings of Wisser et al 1994 reGestational age reading the precision of ultrasound scans to assess Gestational age in the first and second trimester, respectively.[14] In the past, the BPD had been described as a reliable method of determining Gestational age (Campbell, 1969).[3]

The BPD can be taken in the same plane by placing the calipers on the outer edge of proximal calvarium wall and on the inner edge of the distal calvarium wall (Manning, 1999).[11]

The BPD, while highly correlated with HC, is less accurate as a predictor of gestational age. As a result of variation in head shape (Chervenak et al, 1998). Using multiple parameters, the accuracy of Gestational age assessment can be improved.[7]

Sampling and Statistical analyses: Purposively sampling was done. All the relevant collected data were compiled on a master chart first. Statistical analyses of the results were be obtained by using window based computer software devised with Statistical Packages for Social Sciences (SPSS-21) (SPSS Inc, Chicago, IL, USA) Stata.

Scanning technique: The fetal head was frozen in a position in which third ventricle and thalami, were seen. Calipers were placed perpendicular to the parietal bones, outer edge of proximal calvarial wall and other caliper was fixed on the inner edge of distal calvarial wall.

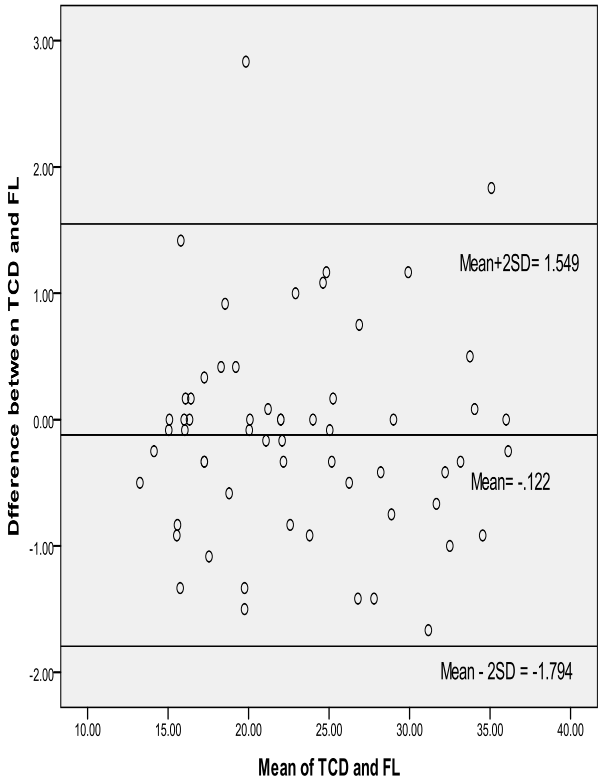
"The biparietal diameter can be taken in the same plane by placing the calipers on the outer edge of the proximal calvarium wall and on the inner edge of the distal calvarium wall- Manning, 1999."[11]

FL was measured in the long axis such that osseous part of the femur is clear without foreshortening.

Proximal and distal epiphyseal cartilages were not taken into measurement.

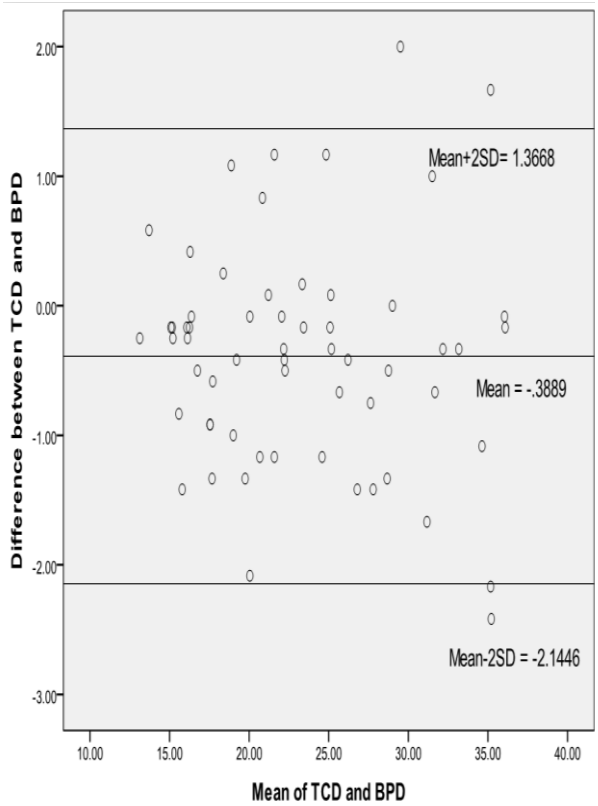
"While not included in the FL measurement, the proximal epiphyseal cartilage (future greater trochanter) and the distal femoral epiphyseal cartilage (future distal femoral condyle) should be visualized to assure that the entire osseous femur can be measured without foreshortening or elongation (Filly and Hadlock, 2000, Goldstein, 1987).[10,15]

RESULTS



Here, mean= -0.122 and SD= 0.7135

Figure I: Distribution of difference between TCD and FL and mean of TCD and FL.



Here, mean=-.3889 and SD=.8778

Figure II: Distribution of difference between TCD and BPD and mean of TCD and BPD.

Table 1: Distribution of the correlations between EGA, TCD, BPD and FL.

Correlations		**EGA**	**TCD_Y**	**BPD_Y**	**FL_Y**
GEGESTATIONAL AGE	Pearson Correlation	1	.993**	.998**	.998**
	Sig. (2-tailed)		.000	.000	.000
	N	60	60	60	60
TCD_Y	Pearson Correlation	.993**	1	.991**	.992**
	Sig. (2-tailed)	.000		.000	.000
	N	60	60	60	60
BPD_Y	Pearson Correlation	.998**	.991**	1	.993**
	Sig. (2-tailed)	.000	.000		.000
	N	60	60	60	60
FL_Y	Pearson Correlation	.998**	.992**	.993**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	60	60	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2: Distribution of the correlation TCD and EGA.
Model Summary and Parameter Estimates
Dependent Variable: TCD_Y

Equation	**Model Summary**					**Parameter Estimates**	
	R Square	**F**	**df1**	**df2**	**Sig.**	**Constant**	**b1**
Linear	.986	4227.395	1	58	.000	-.007	.989

The independent variable EGA

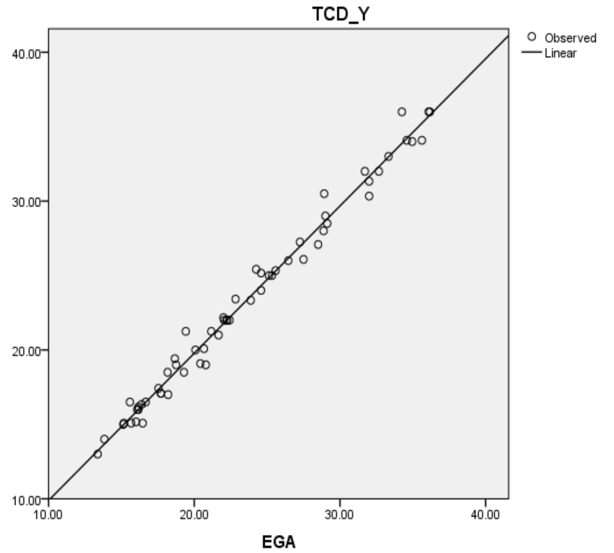


Table III: Distribution of the correlations between EGA and TCD_Y.

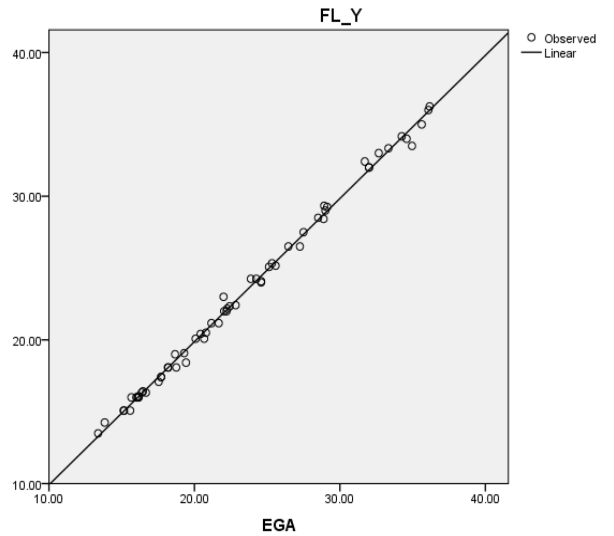


Table IV: Distribution of the correlations between EGESTATIONAL AGE and FL_Y.

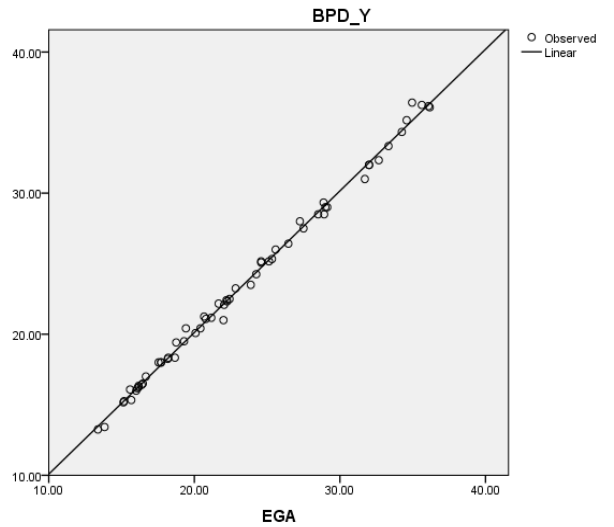


Table V: Distribution of the correlations between EGA and BPD_Y.

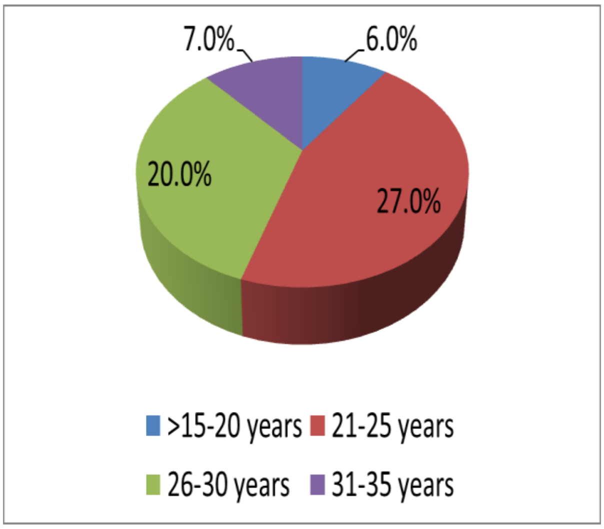


Figure VI: Pie chart of the age distribution.

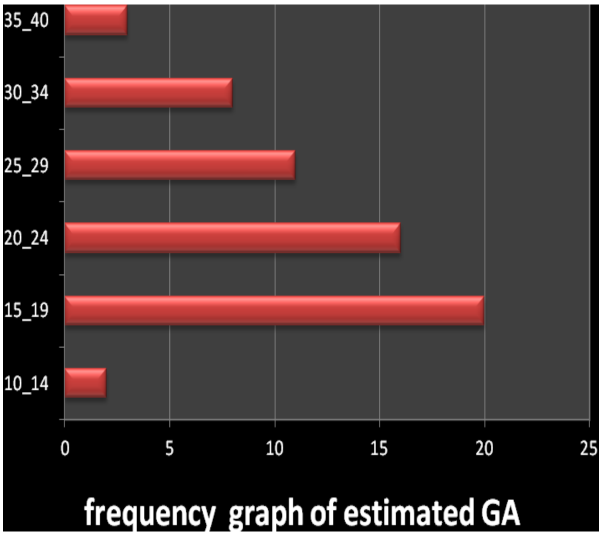


Figure VII: Bar diagram of the estimated Gestational age.

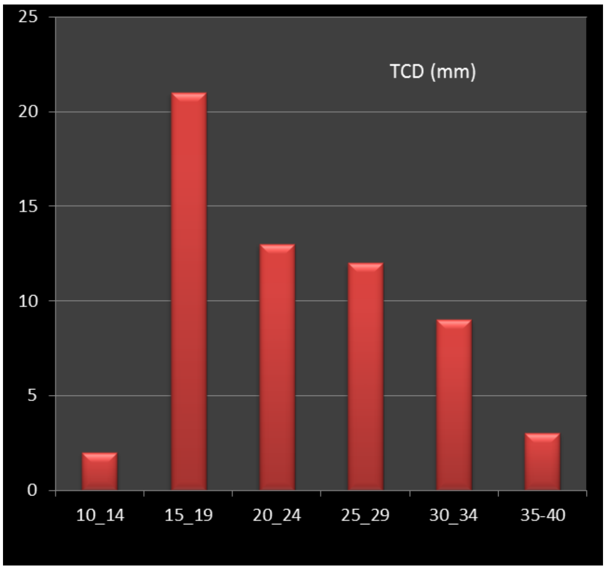


Figure VIII: Bar diagram of the TCD measurements.

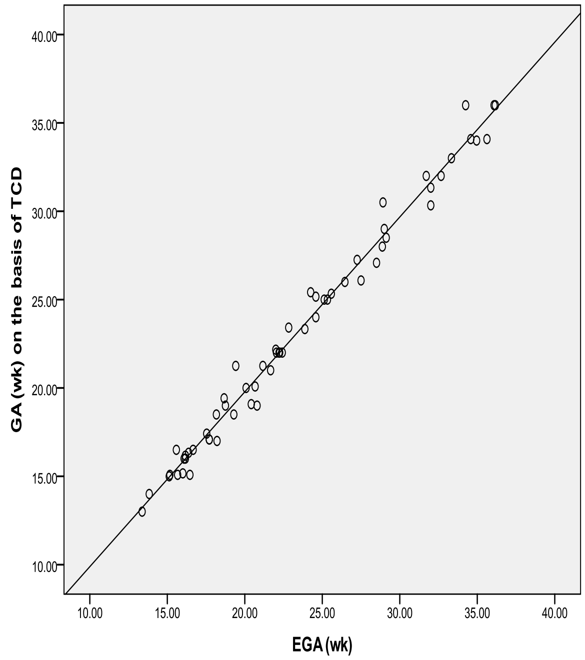


Figure IX: Distribution of the correlations between Gestational age by estimated using gold standard para meters and Gestational age estimated by TCD.

DISCUSSION

To construct the nomogram, separate linear regression models for the mean and SD were fit on the basis of gestational age. The regression model for the mean was best fit by allowing a first-degree polynomial equation for gestational age of the form: $y = a + bx$ where a is the intercept and corresponds to that value of y where $x = 0$ and b is the slope of the curve and describes the rate of change of y for a given x. In diagnostic ultrasound, one rarely needs to go beyond a third order or cubic relationship.

To assess the quality of mathematic relationship derived by a regression analysis, a series of statistical parameters are used. Correlation coefficient [r]- is a measure of association between the dependent variable and the independent variable. The greater the value of r, the stronger the association. Variance [r^2] is a means of describing how much of the y variable is explained by the x variable. It is the best measure when assessing the strength of the association between y and x. Standard error of estimate [SEE] - is a measure of variability and is the standard deviation of the residuals. Residual is the difference between the observed values of the outcome variable and the fitted values based on a linear regression analysis. Residual analysis is particularly important in confirming homoscedasticity where the variance of y is the same for all values in x.

Differences in the performance of BPD, TCD, and FL, TCD in prediction of GA were compared. At each given gestational age, the measurement was assessed. The difference between estimated measurement at each gestational age verses that of Hadlock was performed.

In this thesis p value-, r-value weighted kappa value. These values are giving strong correlation between the parameters used for estimating Gestational age. It is inferred that TCD can be used interchangingly with a gold standard para meters like FL and BPD in estimation of Gestational age. This result can be used appropriately in the patients with suspicious of skeletal dysplasia where the length of femur is deformed or the BPD is deformed. In skeletal dysplasia the TCD is the appropriate parameter to estimate Gestational age as cerebellum escapes any growth retardation or skeletal dysplasia.

The cerebellum lies in the posterior fossa and is surrounded laterally by the dense petrous ridges of the temporal bones and inferiorly by the occipital bone. The petrous ridges are aligned perpendicular to the plane of maximum extrinsic compression experienced in utero by the foetal head. Thus the cerebellum and posterior fossa are more resistant to deformation by extrinsic pressure than the parietal bones and the corresponding bi-parietal diameter (Losser 1972).[16]

Using ultrasound, several authors have observed that the biparietal diameter may be affected by variations in the shape of the skull (Kasby & Poll 1982).[17] McLeary (1984) have found on ultrasonography of the foetal skull that the posterior fossa is not affected by the pressure effects, and that cerebellar diameter is a more accurate reflection of Gestational age than biparietal diameter particularly in the presence of abnormal skull shapes like brachycephaly and dolichocephaly.[18]

Goldstein et al., (1987) found in a foetal ultrasonographic study of 335 foetuses of varying GESTATIONAL AGE that sonographic visualization of the cerebellar growth reveals a linear relationship during the second trimester. Thus the measurement of TCD in millimetres is approximately equal to the gestational age in weeks during this period. The rate of growth decreases towards term.[19]

Cabbad et al. found that 22 out of 23 asymmetrically growth impaired foetuses had a TCD lower than expected but within the normal range (Cabbad et al., 1992) suggesting that this measurement could be used to help estimate gestational age in these cases.[20]

A prospective ultrasonographic study of 19 intrauterine growth retarded foetuses showed that the growth of the TCD is unaffected by intrauterine growth retardation. Thus the sonographic measurement may serve as an independent and reliable correlate of GA against which potential deviations of growth may be compared (Shimizu 1992).[21]

Another study of ultrasound measurements of TCD in twin and triplet pregnancies demonstrated that, unlike other biometric values, only the TCD measurement remains relatively unaffected by discordant growth in twin and triplet gestations (Goldstein & Reece 1995).[22]

TCD is another new and unique parameter, well established in the ultrasound literature as a reliable and it is consistently superior in predicting GA in both singleton and twin gestation (Chavez et al., 2003; Chavez et al., 2004; Chavez et al., 2006).[23,24]

Conflict of Interests

The authors declare that there is no conflict of interests regarding publication of this paper.

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