Role of transcerebellar diameter in prediction of gestational age in IUGR pregnancies

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Abstract

Background: Ultrasound measurement of biparietal diameter "BPD", head circumference "HC", abdominal circumference "AC" and femur length "FL" can accurately detect gestational age "GA" in normal pregnancies. The study aims to assess the accuracy of transcerebellar diameter "TCD" in estimating the GA in normal and intra-uterine growth restriction "IUGR" pregnancies.

Methods: A cross-sectional study was carried out on 30 pregnant women with normal pregnancy (group A) and 30 pregnant women with IUGR (group B). Ultrasound measurement of fetal biometry was done, including the following parameters: BPD, HC, AC, FL and TCD.

Results: Regression analysis for GA by date using different measures among the normal group showed that TCD had the highest determination (0.886), which increased to 0.958 when TCD was combined with FL and AC. On the other hand, regression analysis for GA by date among the IUGR group showed that TCD had the highest determination (0.988), which increased to 0.990 when TCD was combined with BPD.

Conclusion: Fetal TCD is a more reliable method in the 3rd trimester of gestation to determine the GA than BPD and other biometric measures, especially in IUGR pregnancies.

Keywords: Transcerebellar diameter; Gestational age; IUGR; Fetal biometry.

INTRODUCTION

Accurate estimation of the gestational age "GA" is important for evaluating pregnancy progress and fetal development, as well as for proper planning of adequate intervention or management. Before sonography, obstetricians had relied on the last menstrual period (LMP) to estimate the GA (1).

Though LMP has been shown to correlate with GA, it may be a deceptive indication because only approximately half of women can reliably recall their LMP (2). Therefore, ultrasound has been used to detect GA accurately (3). The biometric parameters, including biparietal diameter

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"BPD", head circumference "HC", abdominal circumference "AC" and femur length "FL", could be reliable in measuring GA. The accuracy of these metrics is dependent on the fetal skull shape, placental location, fetal head flexion, engagement, maternal adiposity, and gestational multiplicity. However, such measurements are affected by abnormal fetal growth (4).

Intra-uterine growth restriction (IUGR) is considered when the estimated fetal weight "EFW" is below the 10th percentile and the AC is below the 2.5th percentile for the GA by dates. It is believed that, under normal conditions, each fetus has a precise growth potential appropriate with GA. However, in IUGR cases, the neonate is born with a smaller head and/or abdomen than normal (5). Antenatal recognition of IUGR is crucial because of being linked with increased intra-uterine fetal death "IUFD" and fetal morbidity, including brain damage, fetal distress, newborn hypothermia, hyperbilirubinemia, hypoglycemia, and reduced immunological function (6).

Owing to the brain-saving phenomena that lead to prolonged brain blood flow at the expense of systemic supply, the cerebellum is least affected by IUGR. Moreover, it is relatively resistant to hypoxia. Transcerebellar diameter (TCD) is the distance between the cerebellar lateral aspects that includes the breadth of the cerebellar vermis on the axial scan (7). Because of its anatomical placement in the posterior cranial fossa, the cerebellum is less susceptible to anomalies in embryonic growth, such as growth acceleration or limitation (8). TCD is considered a reliable parameter for estimating the GA, as there is a link between the dimension of the fetal cerebellum, particularly the TCD, and the GA (9).

Consequently, this study was conducted and aimed to assess the accuracy of TCD in estimating the GA in normal and IUGR pregnancies.

METHODS

This cross-sectional study was carried out at the Department of Obstetrics and Gynecology, Kasr El Aini Hospitals, Cairo University, from January 2022 to January 2023, during which about 60 pregnant women were included for antenatal care. The Research Ethics Committee (REC), Faculty of Medicine, Cairo University approved this study under registration number (MS-631-2021). The included women had signed written informed consent before participating in the study after being informed of its purpose. All participants had the right to withdraw from the study without being adversely impacted regarding the medical care they should receive.

Eligibility criteria for the enrolled pregnant women in this study included singleton pregnancy, GA of 28- 40 weeks (based on the first day of LMP of regular menstrual cycles or documented first-trimester or early second-trimester ultrasound scan). Women were excluded if they were unsure of dates or in case of fetal anomalies, multifetal pregnancy, or intrauterine fetal death (IUFD).

Women were allocated into 2 equal groups; "Group A" which included pregnant women with normal fetuses, and "Group B" which included pregnant women with IUGR fetuses. All women were subjected to detailed medical history and clinical examination to ensure adherence to inclusion criteria. During antenatal transabdominal ultrasonography, patients were positioned with the head of the bed elevated 30 degrees and a little cushion under their right loin procedures. To assure the accuracy of the test results, all ultrasound exams were performed utilizing 2-dimensional ultrasonography by knowledgeable and experienced medical experts.

Ultrasound measurements of fetal biometry included the following parameters:

- BPD was measured on a section plane

that passed across the thalami and 3rd ventricle. In the sectional plane, the calvarium seemed symmetrical and smooth. The abdominal transducer was positioned perpendicular to the fetal parietal bones in order to get the proper picture. Next, the cursors were positioned on the inner and outer edges of the distal and proximal skulls, respectively. This length was indicative of the BPD.

- HC was obtained in the plane passed across the thalami and 3rd ventricle, similar to the plane for the BPD. To achieve the most accurate measurement, we cared to visualize other intracerebral markers, such as the cavum septum pellucidum anteriorly and the tentorial hiatus posteriorly. This view depicted the cranium's greatest anterior-posterior length and resembled an "arrow" with the anterior portion appearing as tail feathers, the third ventricle and Sylvian aqueduct as the shaft, and the actual arrowhead comprised of the ambient and quadrigeminal cisterns and the tentorial hiatus as the actual arrowhead. The cerebellum and lateral cerebral ventricles were not included in the usual picture.
- FL was obtained in line with the femur long axis. The proximal end of the femur's greater trochanter or the proximal end of the femur's femoral condyle were visible to achieve the correct image. To measure solely ossified bone, the calipers were positioned at the point where bone and cartilage meet.
- AC was obtained at the level of the fetal liver's maximum diameter, which was identified by the "hockey stick"-shaped site where the right and left portal veins united. This plane was selected because there is a strong correlation between the liver's size and the total fetal growth. The proper plane was verified by observing the left portal vein's umbilical segment at its smallest length.
- TCD was obtained by rotating the transducer to about 30º from the trans-axial plane, identifying the thalamus, the cavity of the septum pellucidum, the third ventricle, and the cisterna magna. This was done after locating the cerebellum in the posterior fossa. The largest measurement was obtained by positioning the electronic calipers on the cerebellar hemispheres' outside borders.
- The ultrasound machine derived GA and EFW from the measured biometric parameters. The GA and EFW were estimated according to the following formulas:

  - GA (weeks) = 10.6 − 0.168×BPD + 0.045×HC + 0.03×AC + 0.058×FL + 0.002×BPD2 + 0.002×FL2 + 0.0005×(BPD×AC) − 0.005×(BPD×FL) − 0.0002×(HC×AC) + 0.0008×(HC×FL) + 0.0005×(AC×FL).

  - Hadlock-1 formula: Log10 (EFW) = 1.3596 + 0.0064 × HC+0.0424 × AC+0.174 × FL+0.00061 × BPD × AC-0.00386 × AC × FL [g, cm].

The primary outcome was to assess the accuracy of TCD as a predictor of GA in normal and IUGR pregnancies, while the secondary outcome was to determine the correlation of TCD with BPD, HC, AC and FL in normal and IUGR pregnancies.

Sample size calculation: Sample size was calculated by using PASS 11 program for sample size calculation, setting the confidence level at 95%, margin of error ±0.05, and after reviewing previous study results (10), in which the correlation between TCD and GA was (0.993) in normal pregnancy and (0.995) in intrauterine growth retardation. Based on that, a sample size of at least 60 pregnant women of GA of 28 to 40 weeks was sufficient to achieve the study objective. They were divided into two equal groups: the normal pregnancy group and the IUGR group according to ultrasound fetal biometry and the EFW in relation to GA.

Statistical methods: Data was analyzed using the statistical package for the Social Sciences (SPSS) version 25 (IBM Corp., Armonk, NY, USA). Numerical data were presented in terms of mean ± standard deviation or median and range. Categorical data were presented in terms of frequencies and percentages. Correlations between quantitative variables were done using the Pearson correlation coefficient in normally distributed data and Spearman correlation coefficients in data that are not normally distributed. P-values < 0.05 were considered statistically significant.

RESULTS

Two groups of patients were studied; "Group A" which included normal pregnant women (n=30), and "Group B" which included pregnant women with IUGR fetuses (n=30). Demographic data of the pregnant women and ultrasound measurements of the fetal biometry in both groups are shown in "Table 1".

Table 1: Maternal demographic characteristics and fetal ultrasound measurements

	Normal group "n=30"	IUGR group "n=30"
Maternal age (years)	28.97 ± 6.60 30.5 (18 - 42)	29.70 ± 6.42 30.5 (18 - 40)
GA by date (weeks)	31.03 ± 2.85 30.5 (28 - 38)	31.83 ± 3.50 31 (28 - 39)
BPD (mm)	79.37 ± 6.51 79.5 (69 - 95)	73.60 ± 7.90 71 (62 - 90)
BPD (weeks)	31.73 ± 2.91 32 (27 - 39)	29.43 ± 3.33 28 (25 - 37)
HC (mm)	287.57 ± 23.74 285.5 (259 - 350)	253.03 ± 25.79 248 (223 - 302)
HC (weeks)	32.87 ± 2.57 32.5 (30 - 39)	28.77 ± 3.17 28 (25 - 35)
FL (mm)	59.37 ± 6.03 58 (50 - 75)	54.73 ± 7.19 53.5 (45 - 67)
FL (weeks)	30.40 ± 2.94 30 (26 - 38)	28.33 ± 3.40 27.5 (24 - 34)
AC (mm)	268.83 ± 28.29 265.5 (230 - 344)	238.37 ± 30.53 232 (195 - 295)
AC (weeks)	30.40 ± 2.87 30 (27 - 38)	27.33 ± 2.92 27 (23 - 33)
TCD (mm)	38.23 ± 5.24 36.5 (32 - 50)	38.80 ± 5.31 37.5 (32 - 49)
TCD (weeks)	30.87 ± 2.89 30 (27 - 37)	31.37 ± 2.95 30.5 (27 - 37)
GA by U/S (weeks)	31.10 ± 2.77 30 (28 - 39)	28.23 ± 3.05 27 (25 - 34)

Regression analysis for GA by date using different measures among the normal group showed that TCD had the highest determination (0.886), followed by FL (0.880), then HC (0.841), then AC (0.828), then BPD (0.769). Combining TCD with FL and AC increased the determination to 0.958. On the other hand, regression analysis for GA by date using different measures among the IUGR group showed that TCD had the highest determination (0.988), followed by HC (0.954), then FL (0.949), then BPD (0.920), then AC (0.886). Combining TCD with BPD increased the determination to 0.990.

The correlation between the estimated GA and GA by date in both groups is shown in Table 2. In the normal group, the correlation coefficient was highest in regression combined (0.981), followed by ultrasound combined (0.961), and then regression TCD (0.943). While in the IUGR group, the correlation coefficient was highest in regression combined (0.995), followed by regression TCD (0.994) and then ultrasound TCD (0.986).

Table 2: Correlation between the estimated GA and GA by date in both groups

	Normal group "n=30"		**IUGR group "n=30"**	
	r	P-value	r	P-value
Ultrasound BPD (weeks)	0.883	<0.001*	0.961	<0.001*
Ultrasound HC (weeks)	0.915	<0.001*	0.980	<0.001*
Ultrasound FL (weeks)	0.937	<0.001*	0.984	<0.001*
Ultrasound AC (weeks)	0.897	<0.001*	0.923	<0.001*
Ultrasound TCD (weeks)	0.928	<0.001*	0.986	<0.001*
Ultrasound combined (weeks)	**0.961**	<0.001*	0.985	<0.001*
Regression BPD (weeks)	0.881	<0.001*	0.960	<0.001*
Regression HC (weeks)	0.920	<0.001*	0.977	<0.001*
Regression FL (weeks)	0.940	<0.001*	0.975	<0.001*
Regression AC (weeks)	0.913	<0.001*	0.985	<0.001*
Regression TCD (weeks)	**0.943**	<0.001*	**0.994**	<0.001*
Regression combined (weeks)	**0.981**	<0.001*	**0.995**	<0.001*

The agreement between the estimated GA and GA by date in both groups is shown in Table 3. In the normal group, the interclass correlation coefficient was highest in regression combined (0.990), followed by ultrasound combined (0.980), and then regression TCD (0.970). While in the IUGR group, the interclass correlation coefficient was highest in regression combined (0.998), followed by regression TCD (0.997).

Table 3: Agreement between the estimated GA and GA by date in both groups

	Normal group "n=30"		IUGR group "n=30"	
	Cronbach's alpha	P-value	Cronbach's alpha	P-value
Ultrasound BPD (weeks)	0.938	<0.001*	0.980	<0.001*
Ultrasound HC (weeks)	0.953	<0.001*	0.988	<0.001*
Ultrasound FL (weeks)	0.967	<0.001*	0.992	<0.001*
Ultrasound AC (weeks)	0.946	<0.001*	0.952	<0.001*
Ultrasound TCD (weeks)	0.963	<0.001*	0.985	<0.001*
Ultrasound combined (weeks)	**0.980**	<0.001*	0.988	<0.001*
Regression BPD (weeks)	0.933	<0.001*	0.979	<0.001*
Regression HC (weeks)	0.957	<0.001*	0.988	<0.001*
Regression FL (weeks)	0.968	<0.001*	0.987	<0.001*
Regression AC (weeks)	0.953	<0.001*	0.969	<0.001*
Regression TCD (weeks)	**0.970**	<0.001*	**0.997**	<0.001*
Regression combined (weeks)	**0.990**	<0.001*	**0.998**	<0.001*

DISCUSSION

The brain-sparing phenomenon indicates that blood flow to the brain is sustained at the expense of systemic supply. Therefore, the cerebellum is the least affected in IUGR cases. Moreover, it is relatively resistant to hypoxia. Therefore, we aimed to evaluate the accuracy of TCD in GA assessment, especially in IUGR cases. Our study revealed that TCD had the highest determination for GA in normal pregnancies, followed by FL, then HC, then AC, and then BPD. When TCD was combined with FL and AC, GA determination increased. Additionally, TCD had the highest determination among the IUGR group, followed by HC, then FL, and then BPD. When TCD was combined with BPD, GA determination increased.

Many studies suggested that the TCD could be valuable when GA is unknown or intrauterine growth restriction is suspected. Mishra et al. (2020) determined the precision of TCD measurement in estimating GA in healthy babies in order to create a TCD reference chart based on GA. Ultrasonographic measurements in 300 singleton pregnant women, including BPD, HC, AC, FL and TCD, were studied in a retrospective cross-sectional study. They found that TCD shows a linear correlation to progressing GA in typically growing fetuses. (11).

Kumar et al. (2020) studied 100 cases between

15-40 weeks of gestation. They found that TCD was associated well with other indicators such as BPD, HC, AC, and FL in normal pregnancies. TCD was shown to have the greatest connection with GA when compared to other measures in both normal pregnancies (r = 0.993, p 0.001) and IUGR pregnancies (r = 0.995, p 0.001) (10).

Vedpathak et al. (2020) compared the efficacy of fetal TCD and FL in predicting GA in their study, which included 100 pregnant women. The participants were divided into groups according to their GA. TCD is associated well with other indicators such as BPD, HC, AC, and FL in normal pregnancies. TCD was shown to have the greatest connection with GA when compared to other measures in both normal pregnancies (r = 0.993, p 0.001) and IUGR pregnancies (r = 0.995, p 0.001) (12).

Using the LMP as a reference for the actual gestation time, Sersam et al. (2019) assessed the accuracy of fetal TCD in determining GA in the third trimester of pregnancy. Fetal TCD was measured ultrasonographically in addition to standard measures. GA was estimated using TCD and contrasted with the estimated GA derived from LMP. A statistical investigation revealed a substantial and robust relationship between the estimated GA by LMP and BPD, FL, and TCD, with TCD exhibiting the greatest correlation coefficient (13).

Dashottar et al. (2018) studied 200 pregnant women in the second and third trimesters, including normal and IUGR pregnancies. The results showed that TCD exhibited substantial correlations at 16–20, 20–24, and 24-28 weeks; moderate correlations at 28–32 weeks; and low correlations at 32–40 weeks (14).

Singh et al. (2018) studied 500 pregnant women from 14 to 39 weeks of gestation. The results revealed a statistically significant relationship between TCD and GA in normal and IUGR pregnancies. TCD showed a good correlation with GA in the case of normal pregnancies (correlation coefficient=0.979) and a correlation coefficient of 0.942 in cases of IUGR pregnancies. GA calculated by TCD measurements correlated well with GA calculated by BPD, HC, AC and FL (15).

The study conducted by Eze et al. (2017) included pregnant women in the second and third trimesters of pregnancy. It revealed a significant linear association between TCD and GA acquired from LMP (16). In addition, a previous Egyptian study by Alalfy et al. (2017) was conducted on 60 Egyptian pregnant women in the second and third trimesters of gestation. The study revealed a significant positive correlation between the TCD and the GA by dates (17).

This study's strengths were that it was a cross-sectional analytic study design and that no participants were lost throughout the study period. To assure the accuracy of test results, all ultrasound exams were performed by skilled and competent medical experts. On the contrary, our study had certain limitations. This was a hospital-based research. Another drawback is that our study is limited to the third trimester of pregnancy.

CONCLUSION

Fetal TCD is a more reliable method in the 3rd trimester of gestation to determine the GA than BPD and other biometric measures, especially in pregnancies with fetal growth restriction. Future studies on a large scale could emphasize using combined TCD with femur length and abdominal circumference to determine GA in late pregnancy accurately.

DECLARATIONS

Competing interests: The author has no financial or other conflicts of interest.

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Informed consent: All women gave their consent after being informed of the study's objective and design, and they were given the option to leave the study at any time.

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