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Fetal Trans-Cerebellar Diameter to Abdominal Circumference (TCD/AC) Ratio in Assessment of Gestational Age for The Prediction of Normal Fetal Growth and Intrauterine Growth Restriction

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Abstract:

Background: An accurate gestational age (GA) is the most critical parameter required for the proper management of expectant women. The head circumference (HC), abdominal circumference (AC), biparietal diameter (BPD), and femoral length (FL) are fetal biometric parameters that are frequently employed. These parameters are nonspecific and are contingent upon precise perinatal growth measurements and actual menstrual age. This study aimed to Evaluation of GA for the prediction of normal fetal growth and intrauterine growth restriction (IUGR): Evaluate the precision of the fetal trans-cerebellar diameter (TCD)/AC ratio. **Methods**: This a cross-sectional study included 100 pregnant women. All patients underwent routine obstetric ultrasound scanning. **Results:** A significant positive correlation between TCD/ AC and BPD (r=0.065, P= 0.048), FL (r=0.246, P=0.013), HC (r=0.234, P=0.019), TCD (r=0.275, P< 0.001) and a significant negative correlation between TCD/ AC and AC (r=- 0.770, p< 00001). TCD/AC with area under curve of 0.869 can significantly predict the incidence of IUGR (P<0.001), at cut off value of >13.7, with 71.79% sensitivity, 80.33% specificity, 70% positive predictive value and 81.7% negative predictive value. **Conclusion:** TCD to AC ratio can be used to assess GA because it had high accuracy in predicting the incidence of intrauterine growth retardation at cut off value of >13.7. Neonates with intrauterine growth retardation may have low fetal biometric parameters, FL, HC, AC, and TCD.

Keywords: Normal Fetal Growth; Fetal Trans-Cerebellar Diameter; Abdominal Circumference; TCD/AC, Gestational Age; Intrauterine Growth Restriction.

Introduction

It is essential to have an accurate gestational age (GA) to administer expectant mothers, the right medication. Pregnancy management relies on accurate gestational age (GA) determinations for important decisions like when to induce labor and whether to perform a caesarean section. Due to their reliance on accurate measurements of embryonic growth and real menstrual age, the most commonly used fetal biometric parameters—the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femoral length (FL) are generic [(1)]. Post-maturity, preterm delivery, and low birth weight are all linked to uncertain GA. Due to the fact that some women may be unable to accurately recall the date of their last menstrual period (LMP), Naegele's rule, a widely recognized method for estimating the date of delivery, is subject to certain limitations [(2)].

Ultrasound is the most reliable method to establish pregnancy dating, particularly first-trimester ultrasound confirmation of GA obtained by LMP is made by ultrasound especially when there is discrepancy between fetal measurements [(3)]. To this day, ultrasonography (USG) is an integral part of fetal growth assessment. Several studies have shown that the ratio of FL to AC (FL/AC) and the ratio of TCD to AC (TCD/AC) are growth parameters that do not depend on age [(4)]. Because BPD stops being accurate in situations where the skull's shape changes beyond 26 weeks, there are limitations to these criteria. The parameter FL is unreliable for estimating GA in cases of achondroplasia due to its abbreviated length [(5)].

The development of a new parameter for determining GA was achieved for TCD. The normal development and growth of the cerebellum have been observed to reflect the fetal growth pattern in certain studies. As a result, TCD is employed to ascertain the fetal age [(6)]. Using ultrasound, doctors can see the cerebellum of a developing fetus as early as 10–11 weeks into the pregnancy. The proliferation of GA begins to correlate linearly with it during the second trimester and continues thereafter. Because of its closeness to dense petrous bone, TCD can assess GA in the third trimester and is thus the least affected by environmental factors. The cerebellum is one of the parameters that is least impacted by fetal growth restriction because it keeps its size. Consequently, TCD can be used to make reliable GA predictions [(7)].

Both perinatal mortality and morbidity are increased in the presence of intrauterine growth retardation (IUGR). The risk of perinatal mortality and morbidity is reduced by the early detection of IUGR, which enables improved delivery timing, prenatal monitoring frequency, and early neonatal care (8). In the early detection of asymmetrical IUGR, the ratio of FL to AC is advantageous. Since symmetrical IUGR impacts both FL and AC, its effectiveness is debatable. For 14–42 weeks, the TCD/AC cut-off values stay the same across studies, ranging from 15.4 to 15.98 [(9)].

This study sets out to determine how well GA predicts normal fetal growth and intrauterine growth restriction (IUGR) by analyzing the fetal TCD/AC ratio.

Patients and Methods

This cross-sectional study, which was conducted from April 2024 to May 2025, comprised 100 expectant women who were admitted to the Radiology Department and who attended the antenatal outpatient clinic at the Qaha specialized hospital in Egypt.

The patients provided written consent that was informed. The purpose of the study was to explain to each patient, and they were assigned a secret code number. The investigation was conducted with the consent of the investigation Ethics Committee at the Faculty of Medicine at Benha University.

Inclusion criteria were single pregnancies of 18-40 weeks with known last normal menstrual period or confirmed by early documented USG,

Exclusion criteria were expectant women who were uncertain about their dates, multiple pregnancies, congenital malformations, and were pregnant before 18 weeks or after 40 weeks.

All studied cases were subjected to the following: Detailed history taking including: [Personal history including (age, marital state), parity, present history of chronic diseases, past history of diabetes mellitus (DM) and hypertension (HTN) and)]. Estimation of GA including computed using the most recent normal menstrual period date and confirmed by a first trimester ultrasound examination

Routine obstetric ultrasound scanning:

To assess embryonic biometry, presentation, amniotic fluid volume, placental location, and the exclusion of fetal anomalies, transabdominal ultrasound is administered during gestational age (GA). This is accomplished by employing a 7-10 MHz instrument (Voluson 730 PRO, GE Healthcare, USA) (Figure 1):

AC view: It is a longitudinal view of the neonate that exhibited the fetal bladder and heart. The fetal spine was observed by sliding the transducer laterally. To acquire a cross-section, the transducer was rotated by 90° at the embryonic stomach level. If the umbilical vein was not visible, the transducer was adjusted by making minor sliding movements to alter the sectional level. Then, the image was frozen (Figure 2A) [(10)].

TCD: Back of the skull was the cerebellum in the suboccipitobregmatic aspect, whereas front of the skull were the anterior lobes of the lateral ventricles and the cavum. This was exactly TCD's position. A little rotation of the instrument toward the fetal neck was performed after the lateral ventricle view for the BPD was acquired. Although the rear lobes of the lateral ventricles were almost entirely obscure, the cerebellum was located immediately after them. In order to determine the TCD, the 'outer to outer' method was used at the cerebellum's widest points, which were positioned at a right angle to the long axis (Figure 2B) [(10)]. Millimeters were employed to quantify all measurements. Divide the TCD by the AC and multiply the result by 100 to ascertain the TCD/AC ratio.

Primary outcome measures:

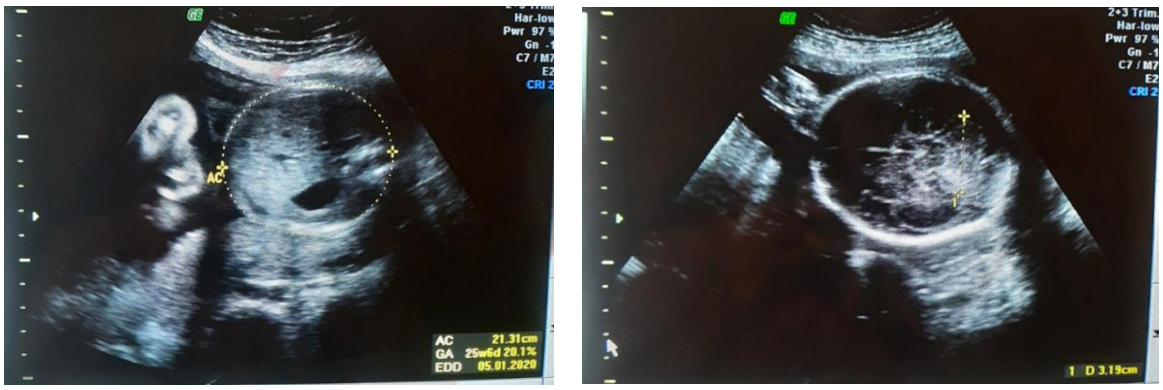
The principal findings involve the evaluation of the fetal TCD/AC ratio in the context of GA assessment to predict normal prenatal growth and IUGR by analyzing the discrepancies between actual and anticipated sonographic biometric measurements for specific GA.

Approval code: MS 23-1-2024

Statistical analysis:

Excel was used for recording, categorizing, and analyzing information gathered from the patient's health record, standard clinical assessment, laboratory results, and outcome metrics. Lastly, version 20.0 of the Statistical Package for Social Sciences was used to import the data for analysis. The significance of the connection was assessed using either Pearson's or Spearman's correlation, contingent upon the data type. Quantitative data is represented using the mean ± SD, while qualitative data is represented using numbers and percentages. Statistical significance was established when the P value was less than 0.05 or 0.001. Their calculations encompassed specificity, predictive potential, and sensitivity.

Figure 1: Routine USG



(A) **(B)**

Figure 2: (A) AC measurements, (B) TCD measurements

Results

Regarding the baseline characteristics, the age of the studied women ranged from 20 to 40 years with a mean of 32.45± 5.43 years. The weight ranged from 60 to 90 Kg with a mean of 75.27± 8.13 Kg, and the BMI ranged from 20.15 to 35.16 kg/m^2 with a mean of 26.29± 3.31 kg/m^2. The GA ranged from 18 to 40 weeks with a mean of 28.3± 6.22 weeks. Among the studied women, 42 (42%) were primipara and 58 (58%) were multipara. The neonatal birth weight ranged from 1.2 to 3.8 kg with a mean of 2.68± 0.83 Kg. Regarding the associated comorbidities, 34 (34%) women had HTN, and 25 (25%) women had DM. **Table 1**

The BPD ranged from 37 to 94 mm with a mean of 65± 16.42 mm. The FL ranged from 18 to 73 mm with a mean of 48.29± 15.45 mm. HC ranged from 135 to 323 mm with a mean of 242.51± 50.36 mm and AC ranged from 105 to 392 mm with a mean of 253.62± 76.48 mm. The TCD ranged from 18 to 45 mm with a mean of 32.33± 6.78 mm and the TCD/ AC ranged from 6.69 to32.38with a mean of 13.86± 4.82. Among the studied women, IUGR was detected in 39 (39%) women, whereas normal growth was detected in 61 (61%) women. **Table 2**

There was a significant positive correlation between TCD/ AC and BPD (r=0.065, P= 0.048), FL (r=0.246, P=0.013), HC (r=0.234, P=0.019), TCD (r=0.275, P< 0.001). There was a significant negative correlation between TCD/ AC and AC (r=-0.770, p< 00001). **Table 3**

TCD/AC with area under curve (AUC) of 0.869 can significantly predict the incidence of IUGR (P<0.001), at cut off value of >13.7, with 71.79% sensitivity, 80.33% specificity, 70% positive predictive value (PPV) and 81.7% negative predictive value (NPV). **Table 4**

Table 1: Baseline characteristics and comorbidities of the studied women

			Total (n= 100)
Baseline characteristics	**Age (years)**	**Mean± SD**	32.45± 5.43
		Range	20-40
	Weight (Kg)	**Mean± SD**	75.27± 8.13
		Range	60-90
	BMI (kg/m^2)	**Mean± SD**	26.29± 3.31
		Range	20.15-35.16
	GA (Weeks)	**Mean± SD**	28.3± 6.22
		Range	18-40
	Parity (%)	**Primipara**	42 (42%)
		Multipara	58 (58%)
	Neonatal birth weight (kg)	**Mean± SD**	2.68± 0.83
		Range	1.2-3.8
Comorbidities	**HTN**		34 (34%)
	DM		25 (25%)

BMI: Body mass index, GA: gestational age, HTN: Hypertension, DM: Diabetes mellitus.

Table 2: Fetal biometric parameter by ultrasound and incidence of IUGR of the studied women

		Total (n= 100)
BPD (mm)	**Mean± SD**	65± 16.42
	Range	37-94
Femur length (mm)	**Mean± SD**	48.29± 15.45
	Range	18-73
Head circumference (mm)	**Mean± SD**	242.51± 50.36
	Range	135-323
Abdominal circumference (mm)	**Mean± SD**	253.62± 76.48
	Range	105-392
TCD (mm)	**Mean± SD**	32.33± 6.78
	Range	18-45
TCD/ AC	**Mean± SD**	13.86± 4.82
	Range	6.69-32.38
Incidence of IUGR	**Normal**	61 (61%)
	IUGR	39 (39%)

BPD: biparietal diameter, TCD: transverse cerebellar diameter, TCD AC: transverse cerebellar diameter abdominal circumference. IUGR: Intrauterine growth restriction.

Table 3: Correlation between TCD/ AC and other parameters

	TCD/ AC	
	r	**P**
BPD (mm)	0.065	**0.048***
Femur length (mm)	0.246	**0.013***
Head circumference (mm)	0.234	**0.019***
Abdominal circumference (mm)	- 0.770	**< 0.001***
TCD	0.275	**< 0.001***

BPD: biparietal diameter, TCD: transverse cerebellar diameter, TCD AC: transverse cerebellar diameter abdominal circumference, r: correlation coefficient, *: statistically significant as p value <0.05.

Table 4: Diagnostic accuracy of TCD/ AC for prediction of IUGR

	Cutoff	Sensitivity	Specificity	PPV	NPV	AUC	P value
TCD/AC	>13.7	71.79	80.33	70	81.7	0.869	<0.001

TCD: transverse cerebellar diameter, AC: abdominal circumference, PPV: positive predictive value, NPV: negative predictive value, AUC: area under the curve, *: statistically significant as p value <0.05.

Discussion

GA is a crucial parameter in obstetrics. Accurate assessment of GA is essential for distinguishing between normal and abnormal fetal growth patterns, thereby facilitating timely identification and management of potential complications. Traditional methods for estimating GA include the use of last menstrual period dates and early pregnancy ultrasound measurements, which provide reliable estimates in the first trimester. However, as pregnancy progresses, individual variations in fetal size can reduce the accuracy of these methods [(11)].

Regarding the baseline characteristics, the age of the studied women ranged from 20 to 40 years with a mean of 32.45± 5.43 years. The GA ranged from 18 to 40 weeks with a mean of 28.3± 6.22 weeks. Among the studied women, 42% were primipara and 58% were multipara.

In the same line, Agrawal et al. [(12)] 85 out of a total of 156 women (85%) were between the ages of 21 and 30, and the study found that their mean age was 24.82 ± 3.31 years.

However, Ashfaq et al. [(13)] The mean patient age was 28.615.72 years, according to the study. The mean approximate GA was 21.96±1.50 weeks.

The weight ranged from 60 to 90 Kg with a mean of 75.27± 8.13 Kg, the height ranged from 1.6 to 1.79 m with a mean of 1.69± 0.06 m. and the BMI ranged from 20.15 to 35.16 kg/m^2 with a mean of 26.29± 3.31 kg/m^2. The neonatal birth weight ranged from 1.2 to 3.8 kg with a mean of 2.68± 0.83 Kg.

BPD ranged from 37 to 94 mm with a mean of 65± 16.42 mm. FL ranged from 18 to 73 mm with a mean of 48.29± 15.45 mm. HC ranged from 135 to 323 mm with a mean of 242.51± 50.36 mm and the AC ranged from 105 to 392 mm with a mean of 253.62± 76.48 mm. The TCD ranged from 18 to 45 mm with a mean of 32.33± 6.78 mm and the TCD/AC ratio ranged from 6.69 to32.38with a mean of 13.86± 4.82.

In alignment with our study, Yang and Lee [(14)], research found that a normal fetus had a TCD/AC ratio of 13.26 between weeks 19 and 34 of gestation.

In difference, Agrawal et al. [(12)] In a cohort of 15 neonates with IUGR, the mean TCD/AC ratio was 14.17 ± 0.89 during early gestation and 15.61 ± 1.18 during late gestation, as determined by the study.

In all women, IUGR was detected in 39% of women, whereas normal growth was detected in 61% of women.

Similar to our data, Tongsong et al. [(15)] study stated that the prevalence of IUGR among the study group was 51.5%.

In contrast with our study Agrawal et al. [(12)] study evaluated use of TCD/AC ratio in predicting IUGR and only 15% neonates had IUGR.

In the same line, Jayaprakash et al. [(16)] According to the research, TCD has a positive correlation with clinical GA, the first best parameter, as well as BPD, HC, AC, and FL. Therefore, TCD is a valid tool for evaluating GA during the third trimester.

Yang and Lee [(14)] In Korean fetuses, the study found that the ratio of GA to TCD and AC is a good predictor of intrauterine growth restriction because of the high correlation between the three variables. Both TCD and AC were found to increase with GA in the study.

The previous result was explained by Tongsong et al. [(17)] who reported that ischaemic exercise-induced glycogen and subcutaneous fat loss occurs early in the course of IUGR. Consequently, AC levels drop precipitously. Consequently, AC is thought of as a sensitive metric for the early diagnosis of IUGR.

TCD/AC with AUC of 0.869 can significantly predict the incidence of IUGR ($P<0.001$), at cut off value of >13.7, with 71.79% sensitivity, 80.33% specificity, 70% PPV and 81.7% NPV.

Similarly, Hussain et al. [(18)] The study determined that a growth parameter of 15.49 (mean) for TCD/AC could be

employed to detect and determine the severity of IUGR.

In difference, Ashfaq et al. [13] In terms of IUGR prediction, the study indicated that TCD/AC achieved a diagnostic accuracy of 88.75%, a sensitivity of 91.3%, a specificity of 87.2%, a PPV of 89.5%, and an overall reliability (RR) of 89.5%. However, they did find that the TCD/AC ratio adequately predicts IUGR in pregnant women. The limitations of the study were relatively small sample size and lack of assessing more parameters such as fetal TCD to FL ratio (TCD/FL).

Conclusion

From our study results, TCD to AC ratio can be used to assess GA because it had high accuracy in predicting the incidence of intrauterine growth retardation at cut off value of >13.7. Neonates with intrauterine growth retardation may have low fetal biometric parameters, FL, HC, AC, and TCD.

Therefore, we recommend assessing TCD to AC ratio to assess the incidence of intrauterine growth retardation, utilizing the same study methodology on further studies larger sample size and multiple centers and assessing more parameters such as fetal TCD to FL ratio (TCD/FL).

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Author contribution

Authors contributed equally to the study**.**

Conflicts of interest

No conflicts of interest

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