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SONOGRAPHIC GESTATIONAL AGE ESTIMATION USING TRANS CEREBELLAR DIAMETER: A COMPARATIVE STUDY IN NORMAL AND IUGR PREGNANCIES

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Abstract

Background:

This study suggest that trans cerebellar diameter is not only a good parameter for estimating gestational age in normal but also in estimation during IUGR pregnancies.

Objective:

To compare and evaluate the accuracy of TCD based gestational age in estimating gestational age with other fetal biometrics in IUGR and non-IUGR patients in second and third trimesters.

Methods:

A cross-sectional study conducted at Hawwa Hospital, Wazirabad, Pakistan for four months from 01 June 2024 to 30 September 2024, including 270 pregnant women in their second or third trimesters. Used a convenient sampling technique and collected data using fetal biometric including Trans-cerebellar Diameter, femur length, biparietal diameter, abdominal

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circumference, head circumference, OFD and LMP. Statistical analyses were done to determine the associations between parameters of IUGR and non-IUGR pregnancies.

Results:

TCD showed highest GA estimation in IUGR cases. Paired t-tests evaluated that GA estimated by TCD showed a large difference for AC (+2.16 weeks) and FL (+2.01 weeks) ($p < 0.001$) in IUGR pregnancies. Pearson's correlation demonstrated a high association between other GA estimation methods and TCD in both groups, having correlations with LMP ($r = 0.979$) and AC ($r = 0.879$) in IUGR. These findings justify the reliability of TCD for GA estimation in IUGR subjects, where traditional biometrics appear to be less accurate.

Conclusion:

TCD displayed a significant correlation with fetal biometrics for estimating gestational age. Its relationship with LMP and resistance to growth disturbances provides valuable insight for obstetric care and reduces the perinatal morbidity and mortality risk.

Keywords:

Transcerebellar diameter, biparietal diameter, Abdominal circumference, Head Circumference, Femur Length.

Introduction

The cerebellum, often called the "small brain," is a brain region that tightly controls movement. It is primarily responsible for advanced movement-related functions [1]. The cerebellum, positioned beneath the cerebral hemisphere and connected to the base of the brain, composing of two hemisphere and a small cerebellar vermix called cereberal cortex exhibiting distinct anatomical features [2]. The cerebellum has a dumb-bell shaped appearance on ultrasound. It is divided into two hemispheres by the centrally located, well-defined, and more echogenic vermis. In the 2nd trimesters, the measurement of the TCD in millimeters has been utilized as a criterion for estimating fetal gestational age. This measurement is numerically correlated with the number of weeks of gestation [3].

The conventional term in pregnancy used to determine the period after conception is gestational age. It is expressed in weeks and extends from the first day of the last menstrual period to the current day. The normal gestation period is 37 to 42 weeks [4]. High accuracy of determination

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of gestation is necessary to manage obstetric patients as many clinical decisions depend upon this indicator. Conversely, a falsely determined gestational age can lead to earlier premature delivery, resulting in an increase in perinatal morbidity and mortalities. Indeed, calculating gestational age based on the mother's recollection of her last menstrual cycle is prone to error [5].

Image 5: Ultrasound image showing calipers measuring Trans cerebellar Diameter that showing 34 w+3d pregnancy.

To estimate the age of gestation in the 2 and 3 trimesters, different measuring parameters are used, such as the femur length (FL), bi-parietal diameter (BPD), abdominal circumference (AC), and head circumference (HC). Various measurements such as trans-cerebellar diameter, length of the foot, kidney length, intra/inter orbital diameters and other long bone lengths have been utilized to estimate gestational age [6]. These alternative measurements may prove beneficial when fetal abnormalities are present or when traditional biometric assessments are challenging to performing a clinical setting, such in cases of uteroplacental insufficiency [7]. A fetus is known to be suffering from intrauterine growth restriction (IUGR) when fetus weighs less than the 10th percentile for its expected gestational age [8].

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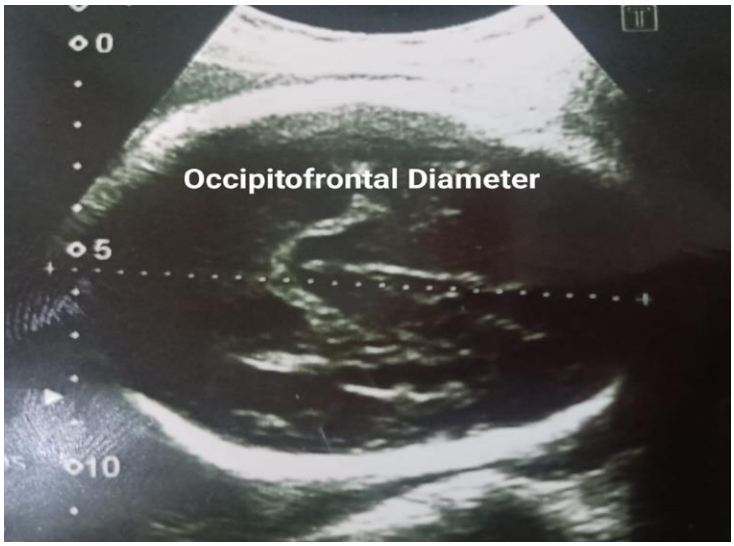

Image 3: Ultrasonic image showing caliper measuring OFD showing 33W+6d pregnancy.

In contrast to fetal overall fetal weight, there is change in the size of the fetal head and body length if a fetal insufficiency occurs in the second and third trimesters [9]. As FL, BPD, and AC. measurements may lack specificity due to their dependence on regular menstrual cycles and typical fetal growth patterns. So, in such cases estimation of gestational age accurately is very important for effective pregnancy management [10]. The aim of this study was to evaluate the accuracy of CD measurements in estimation of gestational age for both normal and IUGR Pregnancies by comparing with fetal biometers in the 2nd & 3rd trimester. We use different statistical methods like standard deviation, correlations and chi-square to find out the relationship between parameters.

Methods.

A cross-sectional study for a period of four months was carried out in the Radiology Department of Hawwa Hospital, Wazirabad Pakistan, from 01 June 2024 to 30 September 2024 with a sample size of 270 participants, calculated via Cochran's formula. We employed a convenient sampling method to recruit pregnant women in their second and third trimesters. Eligibility was determined based on confirmed gestational age, verified through reliable last menstrual period (LMP) records and/or early ultrasound scans. The study included both women with normal fetal

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growth and those suspected of having intrauterine growth restriction (IUGR), identified through clinical assessments and sonographic findings indicative of growth abnormalities. The exclusions comprised women with irregular menstrual cycles, those unable to remember their last menstrual period (LMP), and those who did not want to participate in the study. A variety of data was gathered by means of questionnaires approved from Research Ethical Committee having (Registration: SU91-MSAHW-S23-095) and ultrasound examinations including maternal demographic information and fetal biometric parameters which covered trans-cerebellar diameter (TCD), femur length (FL), bi-parietal diameter (BPD), abdominal circumference (AC), head circumference (HC), and occipital-frontal diameter (OFD). Information was sourced from ultrasound examiners and comprehensive questionnaire information.

Sonographic Examination:

Evaluation was completed by using Toshiba Aplio 500 ultrasound machine equipped with 3-5 MHz convex transducer was used for this study, Quality control is maintained for ensuring the reliability and accuracy of research and clinical results. For ultrasound examination participants lying in a supine position, the couch head is elevated 30^{o} LMP and biometric measurements were used to approximate the gestational age of the participants. Measurement of BPD and HC was taken in transverse plane at the level of thalami and the cavum septum pelucidum, and that of FL was taken as the full bone perpendicular to ultrasound beam while the epiphyseal plate of long bone is excluded while measurement is taken. While AC was calculated in a round section when the stomach is visible while other organs are not included in that section. TCD was measured in the horizontal plane when the butterfly appearance is achieved by rotating the probe keeping in view the landmarks such as thalami and cavum septum pellucidum in the middle. TCD was measured as the widest diameter including bilateral hemispheres from outer portion to other outer margin respectively.

Statistical Analysis:

Data was analyzed using IBM SPSS statistical software version 25 and Microsoft Excel. Descripted analysis was done by using mean and standard deviations to describe dependent and independent variables. Independent Sample t test and paired sample t test were done and

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correlations were checked through Pearson correlation method by setting the significant value $p<0.05$.

Results:

This study included a total of 270 pregnant women, comprising both IUGR and non-IUGR cases. The participants were equally distributed, with 50% diagnosed with IUGR and the remaining 50% classified as non-IUGR. This balanced classification ensured a comprehensive assessment, achieving an overall accuracy of 100%.

Fetal biometric parameters, including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL), are assessed via ultrasound in accordance with international guidelines, such as those established by the International Society of Ultrasound in Obstetrics and Gynecology.

Table 1: Descriptive Statistics of Fetal Biometrics in IUGR vs non-IUGR

Gestational Age Measurement	Group	Mean	Std. Deviation	Min	Max	Skewness	Kurtosis
BPD	IUGR	21.21	3.06	16	30	0.672	0.053
	Non-IUGR	26.21	4.75	16	37	0.458	-0.411
Femur Length	IUGR	19.77	2.52	16	26	0.664	-0.234
	Non-IUGR	26.21	4.89	15	38	0.462	-0.489
Head Circumference	IUGR	21.04	3.08	16	29	0.573	-0.124
	Non-IUGR	26.04	4.97	15	37	0.424	-0.579
Abdominal Circumference	IUGR	19.91	2.68	16	27	0.655	-0.352
	Non-IUGR	25.76	4.71	15	38	0.566	-0.199
Transcerebellar Diameter	IUGR	23.55	2.87	18	34	0.578	0.213
	Non-IUGR	26.45	5.38	15	39	0.566	-0.395
OFD	IUGR	24.61	3.04	19	34	0.398	-0.352
	Non-IUGR	27.61	5.23	17	43	0.494	-0.289

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Table 1: This table presents descriptive statistics for gestational age estimation using various biometric parameters in IUGR and Non-IUGR pregnancies. The findings indicate that IUGR pregnancies generally show lower GA estimates compared to non-IUGR pregnancies. Among the biometric parameters, **Transcerebellar Diameter** and Occipitofrontal Diameter yield relatively higher GA estimates in IUGR, suggesting that they may be less affected by growth restriction. In contrast, Abdominal Circumference and Femur Length show the greatest discrepancies between the two groups, reflecting their strong association with fetal growth restriction. Biparietal Diameter and Head Circumference provide intermediate GA estimates, consistently lower in IUGR. **TCD stands out as a reliable estimator for GA in IUGR** cases due to its minimal deviation compared to other parameters.

Table 2: T-Test for GA by Transcerebellar Diameter: IUGR vs non-IUGR

Comparison of Gestational Ages	Mean Difference	t-value	p-value	Std. Deviation
TCD-BPD	1.285 w	9.260	0.000	2.281
TCD-FL	2.011 w	14.595	0.000	2.264
TCD-HC	1.459 w	11.502	0.000	2.085
TCD-AC	2.163 w	17.036	0.000	2.086
TCD-OFD	-1.111 w	-13.409	0.000	1.362
TCD-LMP	-0.133 w	-2.215	0.000	0.989
TCD-Calculated GA	1.741 w	13.704	0.000	2.087

Table 2: The Paired Samples t-test compares gestational age estimated by Transcerebellar Diameter with other biometric parameters to assess significant differences. The results reveal that TCD provides significantly higher GA estimates than BPD, FL, HC, and AC, with the largest differences seen in AC (+2.163 weeks) and FL (+2.011 weeks), indicating these parameters underestimate GA in IUGR pregnancies. TCD is less influenced by growth restriction, making it a more stable and reliable measure of GA.

Table 3: Comparison of GA by TCD in IUGR vs non-IUGR

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Gestational Age by Transcerebellar Diameter	Levene's Test for Equality of Variances	t-test for Equality of Means			
Constant	**F**	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Equal variances assumed	46.526	.000	-5.534	268	.000
Equal variances not assumed	-	-	-5.534	204.414	.000

Table 3: The Independent Samples t-test compares gestational age by Transcerebellar Diameter between IUGR and Non-IUGR groups, revealing a significant difference (p = 0.000). Levene's Test indicates unequal variances between the groups, so the "**Equal variances not assumed**" results were used. The mean difference shows that GA by TCD in IUGR pregnancies is 2.904 weeks lower than in non-IUGR pregnancies, with a 95% confidence interval of -3.938 to -1.869. The negative t-value (-5.534) confirms that IUGR pregnancies have significantly lower GA estimates by TCD. These findings show TCD as a reliable method for distinguishing between IUGR and Non-IUGR pregnancies.

Table 4: Pearson's correlation for GA estimation in IUGR and Non-IUGR groups.

Gestational Age Estimation Method	IUGR (r-value)	Non-IUGR (r-value)
TCD & BPD	0.742	0.936
TCD & FL	0.895	0.960
TCD & HC	0.757	0.962
TCD & AC	0.879	0.960

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TCD & OFD	0.914	0.962
TCD & Calculated GA	0.855	0.965
TCD & LMP	0.979	0.972

Note: All correlations are significant at **p < 0.01** (2-tailed).

Table 4: Pearson's correlation analysis compares gestational age (GA) estimation methods in IUGR and Non-IUGR groups, showing that TCD has strong correlations with other biometric parameters. In the IUGR group, TCD correlates moderately with BPD (r = 0.742) and HC (r = 0.757), but strongly with AC (r = 0.879) and LMP (r = 0.979), indicating its reliability despite growth restrictions. In the non-IUGR group, correlations are consistently stronger (e.g., TCD & LMP: r = 0.972, TCD & FL: r = 0.960), confirming TCD as a stable GA estimator in normal pregnancies. While slightly weaker in IUGR cases, TCD remains a valuable tool for GA estimation, supporting its clinical applicability.

Discussion:

This study investigated the effectiveness of using Transcerebellar diameter in prediction of estimation of gestational age in normal and intra-uterine growth restricted pregnancies in comparison to traditional fetal biometric parameters like Femur Length (FL), biparietal Diameter (BPD), Abdominal Circumference (AC) and Head Circumference (HC), findings of this study aligns with many studies form recent literature, enumerating the efficacy of TCD as an important tool in fetal biometry.

Also crediting to the findings by **Patial et al. (2022)** where it was concluded that TCD is still a better age marker for IUGR pregnancies and maintained statistically significant correlation with the age in the third trimester ($p < 0.001$). So, their results strengthen the observation that TCD is less sensitive to fetal growth restrictions [11]. Likewise, **Kumar et al. (2020)** established that TCD measurements are much related to Gestational ages in both IUGR and Non-IUGR pregnancies. Their study confirmed that TCD is an independent factor for estimating gestational age, having a correlation coefficient of r=0.995 in IUGR cases and r=0.993 in normal pregnancies [12]. In this study there was the significant association between TCD and IUGR ($p < 0.001$). A consistent finding with the study by **Hamza et al. (2024),** which established TCD as

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a highly significant predictor of IUGR while proving less sensitive to growth disturbances than measurements traditionally considered, such as AC and BPD. In late stage pregnancies, TCD was able to provide clear estimates of gestational age, even when growth restriction set in [13].

Furthermore, **Solyman et al.'s** findings **(2022)** supporting our findings as TCD were found to have high accuracy in cases of IUGR while FL and BPD were least accurate respectively. This reinforces our contention that TCD is a more stable parameter compared with fetal growth restriction [14]. **Bansal et al. (2014)** showing that TCD largely is not disturbed in situations with fetal growth disturbances and can therefore be considered a more unbiased measure of gestational age. They found a strong and significant correlation between TCD and gestational age with a correlation coefficient of 0.972 highlighting the fact that TCD showed a consistent result in growth restricted pregnancies [15]. **Rauf et al. (2021)** said that regardless of whether fetal growth is restricted or not, no differences in TCD measurements have been shown, indicating that TCD is an important measurement to use when BPD and FL are less useful due to head or skeletal disparities [16]. Results of this study supported the findings of **Maher et al. (2022)**, who concluded that TCD showed the highest diagnostic accuracy of 95% in detecting gestational age, in contrast to other biometric parameters. This constant findings of accuracy of TCD with different gestational stages, made this parameter a valuable estimator of GA in clinical settings [17].

The study of **Salem et al. (2022),** reported that TCD accurately estimated gestational age to within ±3 days in 96.4% of cases compared to the accuracy of FL (91.8%), BPD (68%) [18]. Similarly, **Singh et al. (2018),** TCD was found to have a strong correlation with gestational age with correlation coefficients of 0.979 for normal gestation and 0.942 for cases of IUGR and is therefore considered a reliable predictor of fetal growth. As well as the work of **Ali and coworkers (2022)** seemed to confirm these results and have concluded that TCD is positively related to the gestational age than the BPD with an accuracy of 93.6% versus 79.9% for BPD. Suggesting Transcerebellar diameter as a more effective parameter [19]. Our study consistently aligned with these results.

Additionally, **Mourya et al. (2017)** found out that a TCD/AC ratio greater than 15.87% gives an optimal sensitivity and specificity which is consistent with our research results, suggesting the

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importance of this ratio for IUGR screening [20]. The practical importance of TCD in obstetric practice is further illustrated by the data from **El-Ebeisy et al. (2019),** who validated that his technique is highly accurate in predicting gestational age with the greatest accuracy in the early second trimester (98.7%) and late third trimester (68.1%). These findings suggest that while TCD is highly reliable [21] and Independent and paired sample t-Test in our study shows same results.

This study utilized a group of 270 respondents, more than El-Sayed I.e. 52, Uzair et al. with 200 participants, and Bekele et al. with 104 and Bansal et al. with 650.Methods such as correlation analysis as El-Sayed employed and Bansal et al., as well as the multivariate regression by Uzair et al., we calculated the Pearson correlation, paired t-tests, chi-square tests, and logistic regression and results of this study showed Strong correlations of TCD and GA in normal and IUGR pregnancies which is in synchrony to what was reported by El-Sayed and Bansal et al ($r=0.972$, $p<0.001$).The mean GA by TCD (25.00 weeks) was nearly the same as the LMP (25.13 weeks), corroborating its precision. In a similar fashion, Bekele et al. reported significant limits of agreement for TCD, which this study confirms by showing that the deviation of GA estimation in IUGR cases was minimal.

Conclusion:

TCD displayed a significant correlation with fetal biometrics for estimating gestational age. Its relationship with LMP and resistance to growth disturbances provides valuable insight into obstetric care and reduces the perinatal morbidity and mortality risk.

Limitations:

This research is valuable but it has significant limitations as using a convenient sampling technique may lead to potential biasness as it not actually representing the broader population of pregnant women. Especially by excluding women having irregular menstruation or women who are unsure of dates must be included in the study as excluding this is limiting the applicability of findings to all pregnant women.

Recommendations:

Studies with the larger sample size and longer duration must be conducted to include variations in fetal growth patterns and to develop a clear and meaningful configuration across different

population. Probability based sampling methods should be used to reduce biasness. Inclusion criteria must be expanded by including women with irregular menstruation and who are unsure of their dates. In addition to these data on maternal health must be incorporated like medical history and nutritional status and environmental factors that influence fetal growth and fetal biometric parameters.

Competing Interest: The authors declare that they have no competing interests.

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Consent to Participate: Informed consent was obtained from all participants included in the study.

Consent to Publish: Written informed consent for publication was obtained from the participants

Ethical Approval: This study was approved by Research Ethical Committee of Superior University (Registration: SU91-MSAHW-S23-095)

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24. Cerebellar Diameter as A Predictor of Gestational Age of Fetus: Comparison With Other Biometry Parameters

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