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ORIGINAL ARTICLE

Comparative Study of Fetal Transverse Cerebellar Diameter With Biparietal Diameter and Femur Length in the Estimation of Gestational Age in the Second and Third Trimesters

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Abstract

Background: **The management of antenatal care and the successful planning of an appropriate intervention or therapy depend greatly on the determination of gestational age (GA). When dates are ambiguous or there is a suspicion of intrauterine growth retardation, transverse cerebellar diameter (TCD) provides a significant advantage in predicting GA.**

Aim: **To compare TCD measurement to existing fetal biometric measures such as femur length (FL) and biparietal diameter (BPD) to evaluate the diagnostic accuracy of TCD measure in estimating GA throughout the second and third trimesters.**

Patients and methods: **The Obstetrics and Gynecology Department of El-Sheikh Zayed Al-Nahyan Hospital-Specialized Medical Center visited the outpatient clinic to get prenatal treatment. Sample size calculation of a minimum of 300 pregnant women who were divided into three groups (100 pregnant women in each group) were recruited from ultrasound evaluations (transabdominal) using Sonoscope S50, Voloson GE, and Toshiba machines. Routine ultrasound was obtained in about 18 months from November 2020 to May 2022.**

Results: **The findings of the study demonstrated that TCD is more reliable than the BPD and that there is a substantial statistical variation between the TCD and the BPD, as well as between the TCD and the FL, when calculating GA in the second and third trimesters.**

Conclusion: **TCD is a more precise method than the BPD for determining GA in the second and third trimesters of gestation. In the second and third trimesters, TCD and FL can be used as a method to help determine GA.**

Keywords: Biparietal diameter, Femur length, Transcerebellar diameter

1. Introduction

The cerebellum, which is the greatest part of the hindbrain, is situated within the posterior cranial fossa. The structure in question is situated in a dorsal position relative to the pons and the medulla and is anatomically distinct from both by the presence of the fourth ventricle. The anatomical structure known as the tentorium cerebelli serves as a partition between the cerebellum and the cerebrum. The cerebellum is comprised of a central part known as the vermis, as well as two lateral hemispheres. The object exhibits a generally spherical shape, with a slight constriction in its central region and a flattened appearance. The biggest diameter of the object is oriented in a transverse direction.[1]

The cerebellum undergoes development originating from the dorsolateral region of the alar laminae within the metencephalon. During embryonic development, the cerebellum emerges as a prominent enlargement that extends over the fourth ventricle after the fifth week.[2]

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The calculation of gestational age (GA) is a crucial aspect of the care of pregnant individuals. Among the various biometric markers used for estimating GA, the fetal abdominal circumference (AC), biparietal diameter (BPD), head circumference (HC), and femur length (FL) are the most commonly employed.

The limitations of these measures are minimal, as any abnormalities that modify the structure of the skull may impact the BPD, which is well recognized as a marker of GA. The transverse cerebellar diameter (TCD) has emerged as an alternative metric for assessing fetal brain development and estimating GA.

The occipital bone and the thick petrous ridges surround the posterior cranial fossa, where the cerebellum is situated. This anatomical positioning allows the cerebellum to better withstand deformation caused by external pressure compared with the parietal bones. As a result, the TCD has been created as an alternate metric for measuring GA and measuring fetal brain development.

The visualization of the fetal cerebellum using ultrasound has become a standard component of many fetal sonograms due to its ease of imaging, therefore making the examination of the posterior cranial fossa an essential aspect of the procedure.[1]

Multiple authors have researched the TCD and have successfully established a strong correlation between this measurement and GA. This correlation remains significant even in cases of growth retardation. Furthermore, these authors have concluded that the TCD is a superior marker for determining GA when comparing other clinical and biometric criteria.[3–7]

2. Patients and method

A sample size calculation was performed using data from a cohort of at least 300 pregnant women. These women were divided into three groups, with each group consisting of 100 pregnant women. The participants were recruited from my private clinic and the Obstetrics and Gynecology Department at El Sheikh Zayed Al Nahyan Hospital - Specialized Medical Center. The women visited the outpatient clinic to receive antenatal care, and routine ultrasound examinations were conducted over ~18 months.

The study group was categorized into three distinct groups based on the GA of the participants: group 1 consisted of individuals in the early second trimester, namely between 14 and 20 weeks; group 2 included participants in the late second trimester, ranging from 21 to 29 weeks; and group 3 comprised individuals in the third trimester, specifically between 30 and 40 weeks of gestation.

With respect to the participants included in our study, they underwent: the acquisition of transabdominal ultrasound scans to determine GA by standard fetal biometric measures, such as BPD and FL, as well as the assessment of TCD, which will be conducted for about 18 months, spanning from November 2020 to May 2022.

Inclusion criteria were: maternal age from 20 to 40 years (in the childbearing period), GA confirmed by the first day of the last menstrual period in patients who were sure of their dates/or early ultrasound scan, and singleton uncomplicated pregnancy.

The study examines the maternal age range of 20–40 years, which falls within the reproductive era. The GA is calculated using an earlier ultrasound scan or the first day of the last period for people who are confident of their dates. The focus is on uncomplicated pregnancies.

Exclusion criteria were: the study included individuals who exhibited uncertainty over specific dates, individuals who presented with fetal malformations, individuals with multiple pregnancies, individuals with chronic medical conditions such as hypertension or diabetes mellitus, and individuals with pregnancy-induced diseases such as gestational diabetes or preeclampsia.

2.1. Method

The participants who meet the inclusion criteria for this study will be selected from the gynecology outpatient clinic at El Sheikh Zayed Al Nahyan Hospital, a specialized medical center. These individuals will be attending the outpatient clinic for antenatal care and routine ultrasound examinations. Informed consent was gained from the pregnant women, who were selected for participation in the research after a comprehensive explanation of the study's objectives and the procedures that would be conducted. The measurements were conducted on three separate occasions, and the mean values were recorded.

The comprehensive process of gathering historical information, encompassing the individual's personal details, demographic characteristics, complete obstetric history, and menstrual history, involves obtaining specific details such as the first day of the last menstrual period (LMP), documentation of GA, as well as medical and surgical history.

The primary purpose of conducting a transabdominal ultrasound examination was to assess the fetus's BPD, FL, and TCD as indicators for estimating GA. The study incorporated the use of

ultrasound technology to conduct a trans-abdominal ultrasound examination on all participants. The female patients assumed a tilted position, with the head of the bed elevated at an angle of 30°and a little pillow placed beneath the right loin.

2.2. The biparietal diameter (BPD) measurement

2.2.1. The lateral ventricles view was obtained

The skull has a rugby-football-like oblong form, with a rounder occiput and a more pointed synciput. Situated in the center, halfway between the proximal and distal scale echoes. One-third of the space between the synciput and the occiput, or the cavum septum pellucidum, served as the midline division. Around the midline, the two anterior horns of the lateral ventricles are bilaterally positioned. Around the midline, the posterior horns of the lateral ventricles are bilaterally positioned. The measurement of the BPD encompasses solely the thickness of the top parietal bone, as determined by the outer-to-outer distance.

Regarding the transcerebellar diameter measure, the cerebellum would take the place of the posterior horns of the lateral ventricles in the field of view after getting the trans-thalamic image of BPD and slightly rotating the probe downward in the direction of the fetal neck. TCD was assessed by measuring at a 90° angle to the longitudinal axis of the cerebellum, spanning its maximum width, employing the outer-to-outer technique.

In the context of FL measurement, it is essential to obtain an ideal image where the ossified metaphysis is visible at both ends. The length of the ossified diaphysis' longest axis is determined. The methodology used for establishing the reference chart should also be applied when considering the angle between the femur and the insonating ultrasound beams. Typically, an angle of insonation ranging from 45° to 90° is observed. In relation to the location of the caliper, it is important to note that each caliper should be positioned at the extremities of the ossified diaphysis, excluding the distal femoral epiphysis if it is observable. It is imperative to ensure that the measurement excludes any triangular spur artifacts, as their presence may lead to a misleading extension of the diaphysis length.

The optimal sequence for obtaining measurements would involve measuring the belly circumference before measuring the femur. Gently move the probe in a caudal direction starting from the AC section until the iliac bones come into view. At this juncture, a cross section of one or both femurs is typically observed, and it is recommended to use the upper femur for measurement. To achieve optimal visualization of the whole length of the femur and to avoid any obliqueness in the section, soft tissue must be observed extending beyond both ends of the femur. In addition, the bone must not exhibit any merging with the skin of the thigh at any given point. The length of the metaphysis was determined by measuring from the central point of the concave shape at each extremity of the femur bone.

2.3. Ultrasound devices

Fig. 1.

2.4. Statistical methods

The data were analyzed using statistical measures such as mean ± standard deviation (±SD), as well as range. In certain situations, frequencies (number of cases) and percentages were utilized to explain the data. A paired t-test was used to compare the various techniques for determining GA. The evaluation of several variables with respect to the LMP variable was conducted with a margin of error of 1 week. A *P* value of less than 0.05 was deemed statistically significant. SPSS (Statistical Package for the Social Sciences) version 15 for Microsoft Windows was used to do the statistical computations in 2006 Fig. 2.

3. Results

Table 1.

The demographic data in the current study indicated that the pregnant women's age ranged from 20 to 40 years. The estimated fetal weight has a range of 145 g during the early second trimester, gradually increasing to 3025 g Table 2.

The measures of BPD, AC, HC, FL, and TCD during the early second trimester, when connected to GA determined by LMP, exhibit statistically substantial p values. Specifically, the p values were found to be less than 0.001 for BPD, AC, HC, FL, and TCD.

In Table 3, the intraclass correlation coefficient (ICC) values for the correlation between fetal biometry and transcranial Doppler (TCD) measurements, when connected to GA determined by LMP, are presented. In the late second trimester, TCD exhibited the highest ICC value of 0.989. This was followed by BPD with an ICC value of 0.924, HC with an ICC value of 0.920, FL with an ICC value of 0.915, and AC with an ICC value of 0.893 Fig. 3.

In the analysis of fetal biometry and TCD measurements in pregnancies with a GA exceeding 30

Fig. 1. Sonoscape S50 GEVoluson 730 ultrasound equipment.

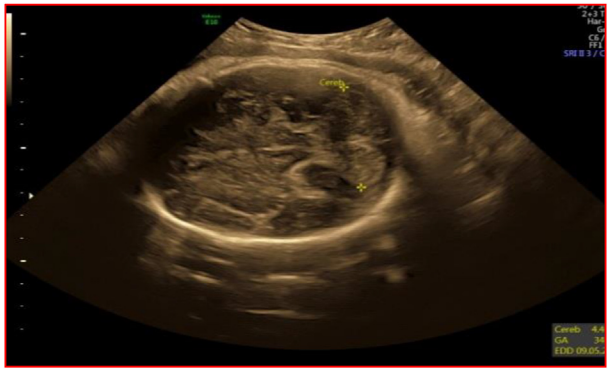

Fig. 2. Transverse cerebellar diameter was assessed in a 23-year-old pregnant woman with a gestational age of 34 weeks + 3 days (from the present research).

Table 2. The present study investigates the correlation between fetal biometrics and gestational age as determined by LMP in a cohort of participants in the early second trimester.

Early second trimester		GA BY LMP (days)
BPD GA (weeks)	*r*	0.818
	***P* value**	<0.001
	N	100
HC GA (weeks)	*r*	0.893
	***P* value**	<0.001
	N	100
AC GA (weeks)	*r*	0.865
	***P* value**	<0.001
	N	100
FL GA (weeks)	*r*	0.884
	***P* value**	<0.001
	N	100
TCD GA (weeks)	*r*	0.934
	***P* value**	<0.001
	N	100

Table 1. Demographic characteristics of the studied groups.

	Mean	Standard Deviation	Minimum	Maximum
GA BY LMP (weeks)	25.59	5.75	15.71	36.00
BPD GA (weeks)	24.81	5.90	15.71	36.29
HC GA (weeks)	25.84	6.33	15.57	38.43
AC GA (weeks)	26.16	6.04	16.14	38.14
FL GA (weeks)	25.75	5.84	15.86	37.00
TCD GA (weeks)	25.59	5.59	15.71	36.00

Table 3. Intraclass correlation coefficients in late second-trimester group with gestational age LMP.

Late second trimester	Intraclass Correlation coefficient	95% Confidence Interval		*P* value
		Lower Bound	Upper Bound	
BPD GA	0.924	0.889	0.948	<0.001
HC GA	0.920	0.883	0.945	<0.001
AC GA	0.893	0.844	0.926	<0.001
FL GA	0.915	0.877	0.942	<0.001
TCD GA	0.989	0.984	0.993	<0.001

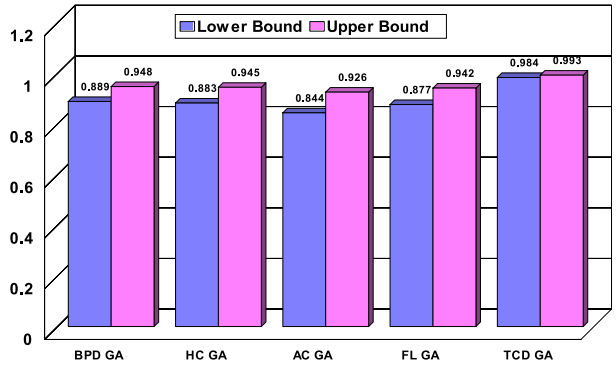

Fig. 3. Intraclass correlation coefficients in late second-trimester group with gestational age LMP.

weeks, the ICC was computed. The results, presented in Table 4, indicate that TCD exhibited the highest ICC value of 0.939. This was followed by BPD with an ICC value of 0.683, HC with an ICC value of 0.652, FL with an ICC value of 0.630, and AC with an ICC value of 0.603 Table 5, Fig. 4.

The utilization of linear regression analysis to assess the precision of BPD in estimating GA when compared with GA determined by LMP demonstrates statistically substantial p values during the early, late second trimester, and for GA exceeding 30 weeks. The corresponding R-square values for these periods are 0.669, 0.855, and 0.505, respectively Table 6, Fig. 5.

Linear regression analysis is used to assess the correctness of the healthcare system. The analysis of GA in relation to GA determined by LMP shows statistically substantial p values (<0.001) for the

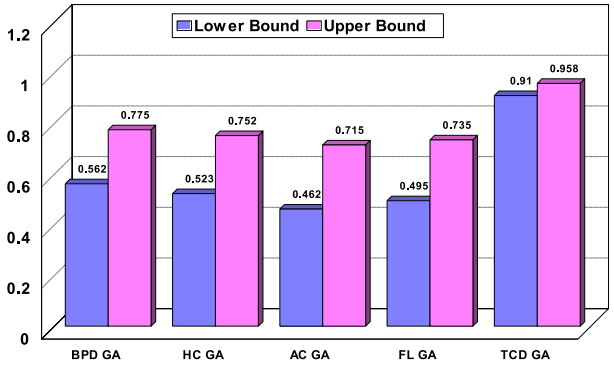

Fig. 4. Intraclass correlation coefficients in gestational age greater than 30 weeks group with gestational age LMP.

Table 4. Intraclass correlation coefficients in gestational age greater than 30 weeks group with gestational age LMP.

>30 weeks	Intraclass Correlation Coefficient	95% Confidence Interval		*P* value
		Lower Bound	Upper Bound	
BPD GA	0.683	0.562	0.775	<0.001
HC GA	0.652	0.523	0.752	<0.001
AC GA	0.603	0.462	0.715	<0.001
FL GA	0.630	0.495	0.735	<0.001
TCD GA	0.939	0.910	0.958	<0.001

Table 5. The application of linear regression analysis is used to identify the gestational age LMP in each group, using the BPD as a predictor variable.

Groups	R Square		Unstandardized Coefficients		Standardized Coefficients	t	*P* value
			B	Std. Error	Beta		
Early 2nd trimester	0.669	(constant)	6.287	0.946		6.644	<0.001
		BPD GA (days)	0.704	0.050	0.818	14.062	<0.001
Late 2nd trimester	0.855	(constant)	2.251	0.925		2.434	0.017
		BPD GA (days)	0.949	0.040	0.924	23.993	<0.001
>30 weeks	0.505	(constant)	15.587	1.731		9.004	<0.001
		BPD GA (days)	0.535	0.053	0.711	9.996	<0.001

Dependent variable: gestational age BY LMP (weeks).

Table 6. Application of linear regression analysis to identify the gestational age of the last menstrual period (gestational age LMP) within each distinct group, using the method of hierarchical clustering (HC).

Groups	R Square		Unstandardized Coefficients		Standardized Coefficients	t	*P* value
			B	Std. Error	Beta		
Early 2nd trimester	0.798	**(Constant)**	5.166	0.733		7.049	<0.001
		HC GA (days)	0.738	0.037	0.893	19.688	<0.001
Late 2nd trimester	0.848	**(Constant)**	3.034	0.914		3.319	0.001
		HC GA (days)	0.877	0.037	0.921	23.413	<0.001
>30 weeks	0.617	**(Constant)**	18.740	1.128		16.618	<0.001
		HC GA (days)	0.419	0.033	0.785	12.563	<0.001

Dependent variable: gestational age BY LMP (weeks).

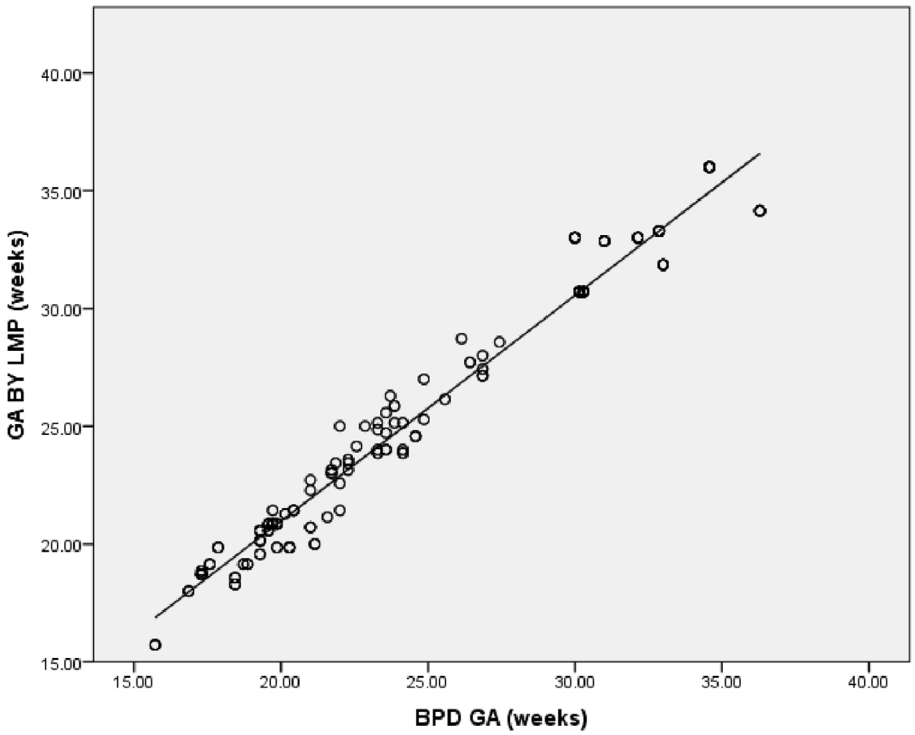

Fig. 5. Intraclass correlation coefficients in gestational age greater than 30 weeks group with gestational age LMP.

early second trimester, late second trimester, and for GA beyond 30 weeks. The corresponding R-square values are 0.798, 0.848, and 0.617, respectively Table 7, Fig. 6.

The use of linear regression analysis to evaluate the precision of HC in estimating GA when compared with GA determined by LMP shows statistically substantial p values during the early

Table 7. Application of linear regression to identify the gestational age of the LMP in various groups using fetal length (FL) as a predictor variable.

Groups	R Square	Unstandardized Coefficients		Standardized Coefficients		t	*P* value
			B	Std. Error	Beta		
Early 2nd trimester	0.781	**(Constant)**	5.491	0.755		7.270	<0.001
		FL GA (days)	0.712	0.038	0.884	18.675	<0.001
Late 2nd trimester	0.838	**(constant)**	1.958	0.998		1.962	0.053
		FL GA (days)	0.913	0.041	0.915	22.520	<0.001
>30 weeks	0.481	**(constant)**	18.209	1.540		11.823	<0.001
		FL GA (days)	0.444	0.047	0.694	9.535	<0.001

Dependent variable: gestational age BY LMP (weeks).

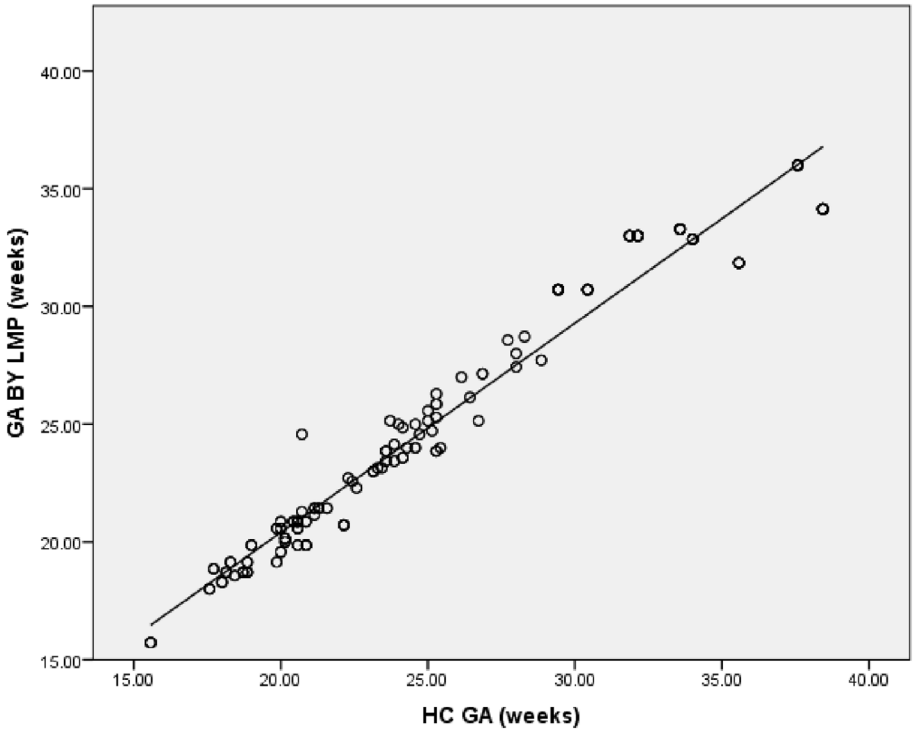

Fig. 6. Scatter dot curve was used to examine the link between gestational age at LMP and BPD measured in weeks across all patients.

second trimester, late second trimester, and for GA exceeding 30 weeks. However, the corresponding R-square values are relatively low, specifically 0.781, 0.838, and 0.481 Table 8, Fig. 7.

The use of linear regression analysis to examine the precision of TCD in estimating GA when compared with GA determined by LMP shows statistically substantial p values during the early second trimester, late second trimester, and for GA measurements exceeding 30 weeks. In addition, the analysis demonstrates the highest R-squared values, indicating superior accuracy in estimating GA using TCD. These values are reported as 0.872, 0.959, and 0.900, respectively, Fig. 8.

4. Discussion

The TCD has been proposed as an alternate metric for assessing fetal biometry. Due to its location within the posterior cerebral fossa, the cerebellum is enveloped by a dense dura and protected by the bony calvarium, rendering it less susceptible to deformation caused by external pressure. Sonographic visualization of the fetal cerebellum can be observed as early as 10–11 weeks. Determination of precise GA, even in the third trimester in cases of intrauterine growth restriction is minimally influenced by factors affecting fetal growth, making the use of TCD a reliable method.[3]

Table 8. Application of linear regression analysis to identify the gestational age of the LMP in each group, using transcranial Doppler (TCD) measurements.

Groups	R Square	Unstandardized Coefficients		Standardized Coefficients		t	*P* value
		B	Std. Error	Beta			
Early 2nd trimester	**0.872**	(constant)	2.420	0.664		3.646	<0.001
		TCD GA (days)	0.867	0.034	0.934	25.874	<0.001
Late 2nd trimester	**0.959**	(constant)	0.169	0.509		0.332	0.741
		TCD GA (days)	0.990	0.021	0.979	47.677	<0.001
>30 weeks	**0.900**	(constant)	6.150	0.900		6.835	<0.001
		TCD GA (days)	0.819	0.028	0.949	29.724	<0.001

Dependent variable: gestational age BY LMP (weeks).

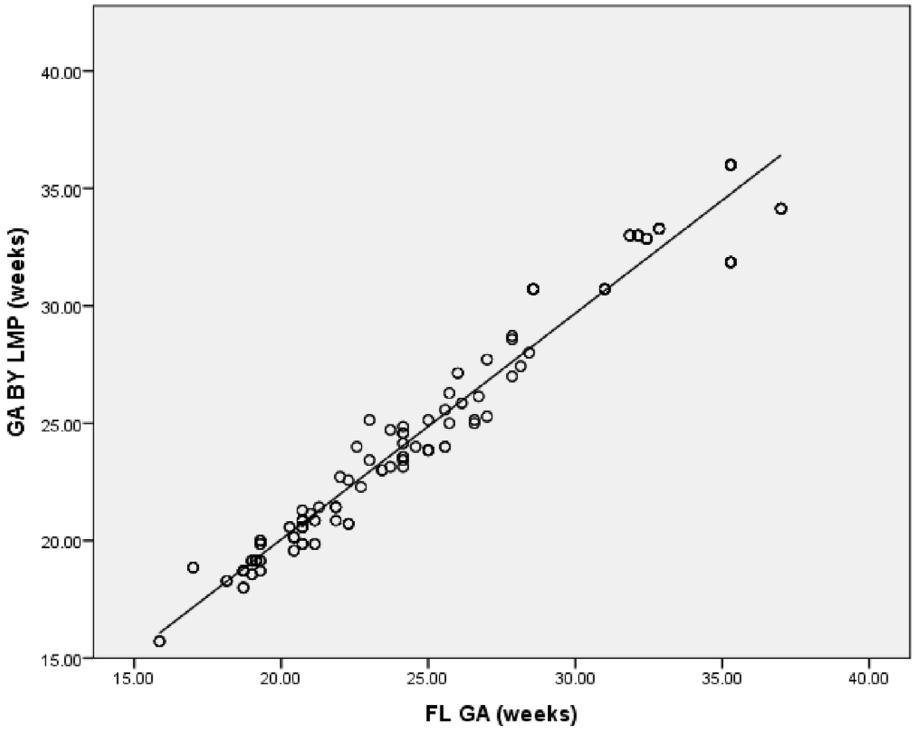

Fig. 7. A scatter dot curve was generated to examine the link between gestational age and low molecular weight heparin (LMP) use in weeks among all patients.

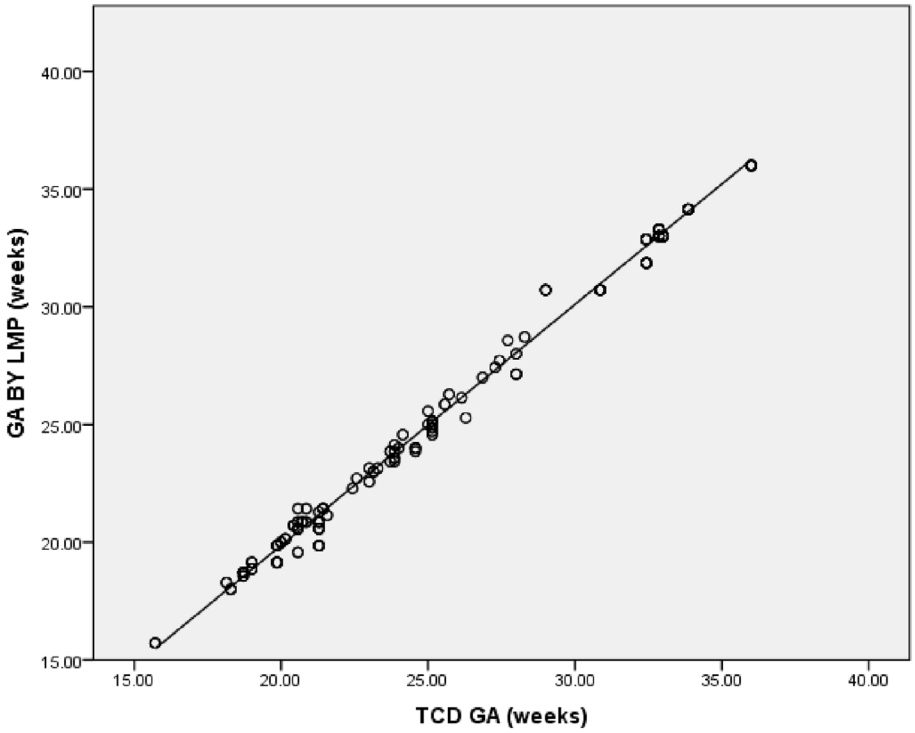

Fig. 8. A scatter dot curve was generated to examine the connection between gestational age and fetal length (FL) in weeks across all patients.

In our investigation, we observed that the average GA in the early secondtrimester, as determined by the LMP, was 19.56 weeks. In contrast, the average GA in the early second trimester, as determined by BPD, was 18.85 weeks. In addition, we found that the average GA, as determined by HC, was 19.5 weeks, by FL was 19.75 weeks, and by TCD was 19.76 weeks.

During the latter part of the second trimester, the average GA determined by LMP was found to be 24.35 weeks. In contrast, the average GA determined by BPD was 23.29 weeks. The average GA determined by HC was 24.29 weeks, while the average GA determined by AC was 24.8 weeks. In addition the average GA determined by FL was 24.51 weeks, and the average GA determined by TCD was 24.42 weeks.

During the thirdtrimester, specifically when the GA exceeds 30 weeks, various methods were used to estimate the median GA. The median GA based on the LMP was found to be 32.85 weeks. In addition, the median GA determined by BPD was 32.29 weeks, the median GA obtained through HC was 33.71 weeks, the median GA calculated using FL was 32.98 weeks, and the median GA derived from TCD was 32.6 weeks. These findings align with a previous study, which compared the median GA obtained from all parameters with that of LMP. Notably, all parameters in the second trimester exhibited GA values that were close to those determined by LMP. The median GA of TCD in the second trimester was found to be 21.12, which closely approximated the GA determined by LMP. During the third trimester, TCD examination showed a median GA that had a stronger correlation with GA determined by LMP. When doing a comparison of the total median GA, it was observed that TCD had a stronger connection with the GA determined by LMP.[8]

The ICC was determined to assess the relationship between fetal biometry and TCD measurements when connected to GA determined by LMP. The results indicate that TCD had the highest ICC value of 0.996, followed by BPD with a value of 0.983, FL with a value of 0.979, and HC with a value of 0.975. The AC had the lowest accuracy, with an ICC value of 0.974. These results are in line with prior research carried out in India, which examined TCD in singleton pregnancies and found that TCD measurements can reliably estimate GA in pregnant women who are uncertain about their LMP. The study reported a strong positive connection ($r = +0.946$, $r^2 = 89.6\%$, $P < 0.001$) between TCD measurements and GA. The progressive rise in TCD measurements during gestation has proven valuable in evaluating the maturation process of the cerebellum.[9]

In this study, the intra-class connection between the TCD and the observed GA demonstrated a high level of agreement. During the second trimester, all parameters exhibited identical levels. During the third trimester, TCD exhibited a stronger intra-class correlation compared with other metrics, which agrees with the results of Naseem *et al*.[10] A study was conducted on a cohort of 228 patients with a GA of 36 weeks, whereby the measurements of TCD and BPD were obtained using ultrasonography. The researchers conducted a comparative analysis of genetic algorithms (GA) implemented using two different techniques: tree-based crossover and mutation (TCD and BPD) and linear model-based prediction. This study conducted an observation of 228 patients, whereby a comparison was made between GA determined by the last menstrual period (GA by LMP) and GA determined by TCD and BPD. The results indicated that TCD accurately determined GA in 209 patients, while BPD accurately determined GA in 176 patients.

Previous research studies, such as those performed by[11] Davies *et al*. have demonstrated that the examination of TCD measures indicates that TCD is a dependable and trustworthy measurement method for determining fetal GA. It is usually regarded as more accurate than other measurements such as HC, BPD, FL, and AC in terms of precision in calculating fetal GA. The method under consideration in this study demonstrates potential as an accurate, dependable, and reliable measurement tool for determining fetal GA in both singleton and twin gestation cases. The study examined the measures of BPD, AC, HC, FL, and TCD in the second and third trimesters of pregnancy. These measurements were connected with GA determined by LMP. The analysis showed statistically substantial p values for BPD, AC, HC, FL, and TCD, which were all found to be less than 0.001. The study included a sample of 228 patients with a GA of 36 weeks, and TCD and BPD were measured using ultrasonography. A comparison was conducted between the genetic algorithm implemented by the technique of tree-structured chromosome decomposition and the technique of binary partition decomposition, with the traditional linear mathematical programming approach. This study involved the observation of 228 patients, whereby the accuracy of GA determination was compared between GA by LMP, TCD, and BPD. The results indicated that TCD accurately determined GA in 209 patients, whereas BPD accurately determined GA in 176 patients.

Another study by Ahmed[12] for assessing the precision of fetal TCD diameter monogram for estimating GA in singleton pregnancies during the second and thirddiscovered that TCD measurement

demonstrates a notable level of accuracy in predicting GA, even during the third trimester of pregnancy. The use of TCD as a significant ultrasonography biometric parameter is advised for the estimation of GA in normal singleton pregnancies. Based on the findings and data gathered from our research, it has been determined and concluded that the TCD method exhibits the highest level of reliability and precision in accurately analyzing and assessing fetal GA. Following the TCD method, the HC method demonstrates a comparable level of precision, while the BPD method follows suit. Subsequently, the FL method ranks next in terms of precision. Lastly, the AC method is identified as the least precise tool for calculating fetal GA. This conclusion exhibits a resemblance to previous research studies, enhancing and reinforcing the dependability of our research outcomes and results.

4.1. Conclusion

The findings of this study demonstrate that TCD is a reliable indicator of GA during the second and third trimesters. The relationship between GA as calculated by the LMP and GA as determined by TCD seems to exhibit a decline in correlation from the second trimester to the third trimester. TCD demonstrates a higher degree of accuracy and serves as a superior predictor of GA when compared with other ultrasonography measures such as BPD, HC, AC, and FL, even during the third trimester.

While FL is indeed accurate, it cannot be relied upon as the sole criterion for estimating GA because of its susceptibility to being influenced by intrauterine growth restriction. The metric known as TCD exhibits the least susceptibility to the effects of intrauterine growth restriction, making it a viable candidate for use as a sole parameter in estimating GA. The findings of our study indicate that the age of the mother does not have a significant impact on TCD, and parity does not seem to influence TCD either.

4.2. Recommendation

Using transabdominal ultrasound and the use of usual fetal biometric measurements, TCD serves as an accurate predictor of GA in the second and third trimesters. The correlation between the LMP-derived GA and the GA by TCD seems to decrease from the second to the third trimester. Even in the third trimester, TCD is a fairly accurate and better predictor of GA in comparison to the other ultrasound parameters such as BPD, HC, AC, and FL.

Therefore, more research must be undetaken to confirm whether TCD is the most accurate measurement for determining the GA of the fetus toward the end of the third trimester.

Conflicts of interest

There are no conflicts of interest.

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