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Original Article

Assessment of Neonatal Gestational Age by Ultrasonographic Transverse Cerebellar Diameter Measurement - A Prospective Cross-Sectional Study

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ABSTRACT

Background: Accurate assessment of gestational age (GA) is important for management and monitoring of neonates. Traditional GA in neonates is assessed mother's first day of last menstrual period (LMP) which can be inaccurate in case of irregular cycle and poor y. Fetal age assessment TCD well studied but studies in neonatal period. The emerging biometric parameter, transverse cerebellar diameter (TCD), offers advantages as it remains unaffected by conditions alter skull shape and antenatal growth fluctuations. Aim to evaluate the effectiveness of TCD measurement neonatal gestational age.

Methods: This prospective cross-sectional study included 112 neonates, spanning preterm and term infants, assessed within 72. Last Menstrual Period (LMP) was used to determine GA. TCD scans were conducted a GE LogiQ-V2 scanner and pediatric curvilinear probe.

Results: There was a statistically significant correlation ($p < 0.0001$) between TCD and gestational age. Linear regression analysis showed 0.4052 change in gestational age per unit change in TCD. Spearman correlation analysis show strong positive correlations between TCD and gestational age ($r = 0.8786$), weight ($r = 0.8242$) and length ($r = 0.8526$). A regression equation based on TCD predict neonatal gestational age. Additionally, TCD demonstrated a very strong positive correlation with asymmetric IUGR ($r = 0.9161$) but a weak positive correlation with symmetric IUGR in relation to gestational age ($r = 0.4761$). Notably, comparisons with other studies in diverse ethnic populations revealed significant differences in TCD findings.

Conclusion: Despite not directly indicating IUGR, TCD shows potential utility in estimating neonatal gestational age as it correlates significantly with advancing gestational a

Keywords: Gestational age, Intrauterine growth restriction, Neonate, Transverse cerebellar diameter, Ultrasonography

Introduction

The human fetal cerebellum undergoes extensive growth from early embryonic stages to the first postnatal years, rendering it prone to diverse developmental challenges (1). Cerebellar growth remains relatively consistent from the end of the second trimester until 18 months marked by accelerated growth (2). The cerebellum which is vital for movement, coordination and cognition, is susceptible to injur during birth (3). The vermis and transverse cerebellar diameter (TCD) at birth are crucial indicators of abnormalities irregular brain development in newborns (4). Gestational age (GA) is pivotal in newborn care, clinical assessment, and prognosis akin to birth weight, clinical measurement New Ballard Score time-

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consuming and observer-dependent, especially in very preterm or sick neonates (5).

In NICUs, routine cranial ultrasound (US) the cotside aids in nondisruptive assessment preterm and critical neonates (6). Intrauterine growth restriction (IUGR), common in 10% of cases, is associated with conditions affect placental circulation, fetal development, maternal health (6). Symmetrical IUGR, linked to early onset and severe etiologies, demands careful GA assessment to avoid misdiagnosis (6). Asymmetric IUGR, associated with late-onset maternal vascular issues or poor nutrition, emphasizes the importance of accurate GA estimation for surveillance and early management decisions to minimize perinatal morbidity and mortality (6). Accurate assessment of GA and fetal growth is crucial obstetric management. Commonly used biometric parameters, including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL), have limitations such as susceptibility to skull shape alterations. TCD a promising biometric parameter for fetal growth assessment as it remains unaffected by changes in skull shape to its deep location in the brain and protection by bony petrous ridges (9). TCD measurements during the fetal stage have shown consistent correlation with GA, even in cases of growth retardation, attributed to the anatomical location, delayed neuronal replication, and linear growth in the second trimester. The effect of early symmetrical IUGR on cerebellar growth remains understudied, lacking strong data for differentiation from late asymmetrical IUGR in both fetal and postnatal periods (6,10,11). Henceforth, this study aimed to estimate the effectiveness of TCD measurement for the assessment of gestational age in neonate and may help in developing a nomogram for GA assessment by measuring TCD in neonates.

Methods

This prospective cross-sectional study was performed the Neonatal Intensive Care Unit and maternity ward of the Department of Pediatrics, spanning 12 months (Nov 2022-Oct 2023). The comprised 112 neonates, covering both preterm and term infants (appropriate for gestational age (AGA), large for gestational age (LGA) and small for gestational age (SGA)), evaluated within 72 hours following ethical approval and informed consent. At the same time, infants with cranio-spinal malformations, moderate-to-severe hypoxic-ischemic encephalopathy or perinatal asphyxia affecting measurement due to brain edema, unknown gestational age (uncertain last menstrual period with no antenatal ultrasound), grade III/IV intraventricular haemorrhage obstructing clear imaging, and those displaying clinical signs indicative of an elevated risk for adverse brain growth or development, such as seizures, encephalopathy, or CNS infections, were excluded from the study. Additionally, neonates with scan abnormalities, except for isolated germinal layer hemorrhage or transient peri-ventricular flares known to be temporary, major malformations or dysmorphism, sepsis, and those with unstable vitals or receiving inotropic support were also excluded.

The TCD was measured using ultrasound on the GE LogiQ-V2 scanner and pediatric curvilinear probe. The probe was placed over the posterior fontanelle in the coronal plane, (Figure1) with the

Figure 1. position of ultrasound probe

cavum septum pellucidum, third ventricle, and thalami visualized as landmarks. The cerebellar hemispheres were visualized by tilting the probe backwards, with TCD measured in the outer-to-outer fashion at the widest diameter (Figure 2). The study ensured consistency by having a single sonologist perform all examinations. The ultrasound was performed within 72 hours of birth for all neonates.

Gestational age was determined based on the mother's last menstrual period (LMP) and confirmed by a first-trimester scan. Neonates were categorized as appropriate for gestational age (AGA), small for gestational age (SGA), or large for gestational age (LGA) using the Fenton growth chart. Intrauterine growth restriction (IUGR) was classified as symmetric or asymmetric based on

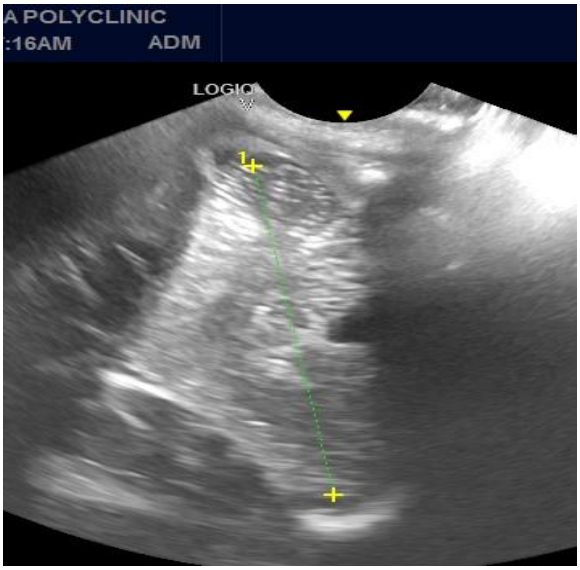


Figure 2. measurement of transverse cerebeller diameter

the ponderal index (PI), with PI ≤ 2.2 indicating symmetric IUGR and PI > 2.2 indicating asymmetric IUGR. The ponderal index was calculated using the formula: weight (g) × 100 / length^3 (cm^3).

Ethical approval

The study was conducted after ethical approval institutional ethic committee (ref no. IEC/VPIMS /12/2022).

Results

The study included 112 neonates, with 64 males (57.1%) and 48 females (42.9%). The mean age of the neonates was 2.04 ± 0.79 days, with a mean gestational age of 36.25 ± 2.48 weeks. The mean weight was 2.53 ± 0.69 kg, and the mean length was 45.98 ± 4.43 cm. The mean TCD was 4.18 ± 0.64 cm (Figure 3). Among the neonates, 65 (58.0%) were term and 47 (42.0%) were preterm. In terms of gestational age classification, 85 (75.9%) were appropriate for gestational age (AGA), 22 (19.6%) were small for gestational age (SGA), and 5 (4.5%) were large for gestational age (LGA). Out of the SGA neonates, 13 (59.1%) had asymmetric IUGR and 9 (40.9%) had symmetric IUGR (Table 1).

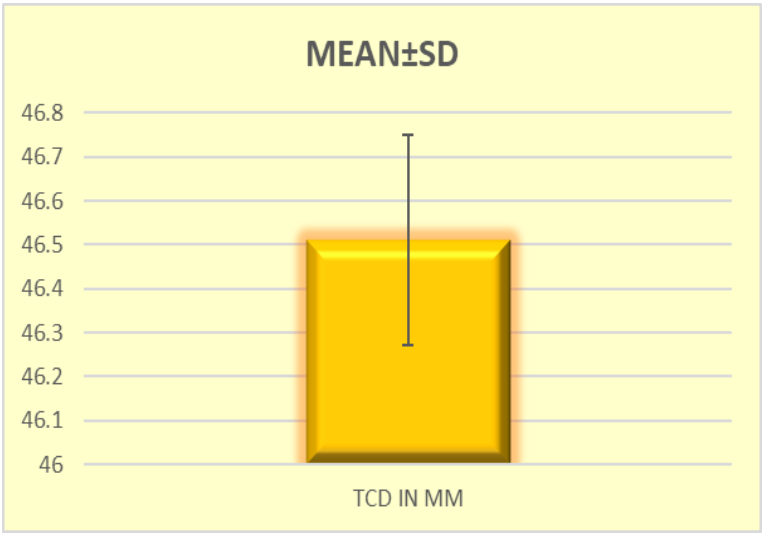


Figure 3. Transverse Cerebellar Diameter (TCD) of the enrolled neonates

Table 1. Demographic parameters of the enrolled neonates

Demographics		N (%)	P-Value
Age (hours)	0-12	35(31.25)	X^2=34.06 p<0.0001*
	12-24	44(39.29)	
	24-36	8(7.14)	
	36-48	12(10.71)	
	48-60	4(3.57)	
	60-72	9(8.04)	
Gender	Female	56(50.00)	X^2=0.00 p>0.9999
	Male	56(50.00)	
Gestational Age Classification	AGA	76(67.86)	X^2=34.88 p<0.0001*
	LGA	7(6.25)	
	SGA	29(25.89)	

*p<0.05, considered significant.

Table 2. Demographic parameters of the enrolled neonates with or without IUGR

Demographical parameters		With IUGR (n=29)		Without IUGR (n=83)		P-Value
		N/ MEAN	%/ SD	N/ MEAN	%/ SD	
Gestational Age (Weeks)	29-31.6	0	0.00%	3	3.61%	x^2=8.039 p=0.2353
	32-33.6	3	10.34%	13	15.66%	
	34-35.6	6	20.69%	17	20.48%	
	35-37.6	8	27.59%	18	21.69%	
	38-39.6	9	31.03%	16	19.28%	
	40-41.6	3	10.34%	16	19.28%	
Gender	Female	12	41.38%	44	53.01%	x^2=1.153 p=0.2829
	Male	17	58.62%	39	46.99%	
Anthropometrics	Weight In gm	1941.55	521.00	2518.04	660.35	t=4.257 p<0.0001*
	Length In cm	45.12	4.08	47.39	4.43	t=2.423 p=0.0170*
TCD (mm)		43.85	5.78	47.74	6.08	t=3.003 p=0.0030*

*p<0.05,considered significant.

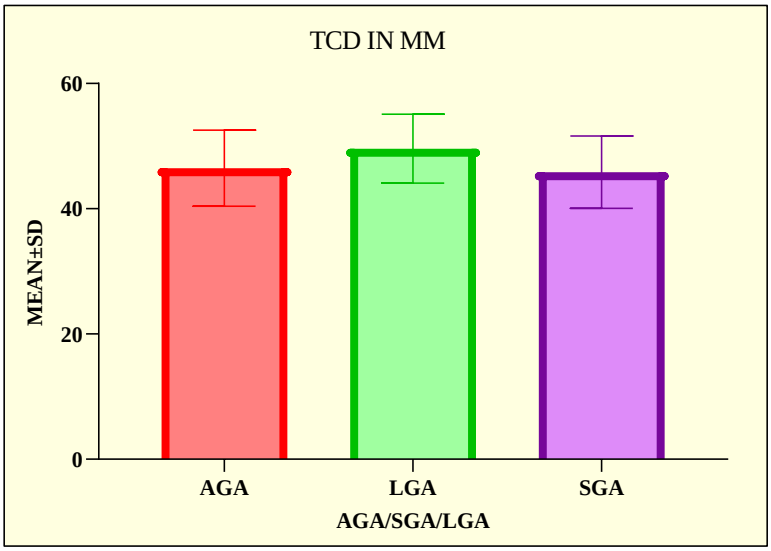
Table 3. TCD value with respect to gestational age of the enrolled neonates

TCD	Gestational Age (in weeks)					
	29-31.6	32-33.6	34-35.6	36-37.6	38-39.6	40-41.6
Mean	37.33	40.79	44.83	49.16	51.85	53.53
SD	0.71	0.75	0.67	0.69	0.64	1.06

There were no significant differences in demographic parameters between neonates with or without IUGR, except for weight and length, which were significantly lower in the IUGR group ($p < 0.0001$) (Table 2).

The TCD values increased with gestational age, showing a mean TCD of 3.12 ± 0.38 cm at 28-32 weeks, 3.92 ± 0.29 cm at 33-36 weeks, and 4.58 ± 0.41 cm at 37-40 weeks (Table 3).

The mean TCD was higher in LGA neonates (49.59±5.50) followed by AGA (48.48±6.06) and SGA (45.85±5.78) (Figure 4).



*transverse cerebellar diameter
AGA-appropriate for gestation age
LGA- large for gestation age
SGA- small for gestation age

Figure 4. TCD* value with respect to gestational age classification of the enrolled neonates

Table 4. Correlation analysis of TCD with various variables of the enrolled neonates

TCD vs.	GA	Weight	Length	Symmetric IUGR	Asymmetric IUGR
Spearman r	0.8786	0.8242	0.8526	0.4761	0.9161
95% confidence interval	0.8263 to 0.9159	0.7515 to 0.8771	0.7903 to 0.8974	-0.02141 to 0.7846	0.7121 to 0.9774
P value	<0.0001*	<0.0001*	<0.0001*	0.0550	<0.0001*

*p<0.05 considered significant.

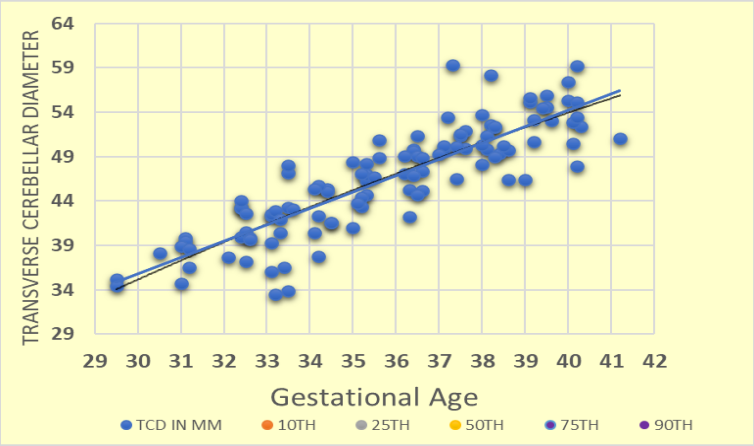
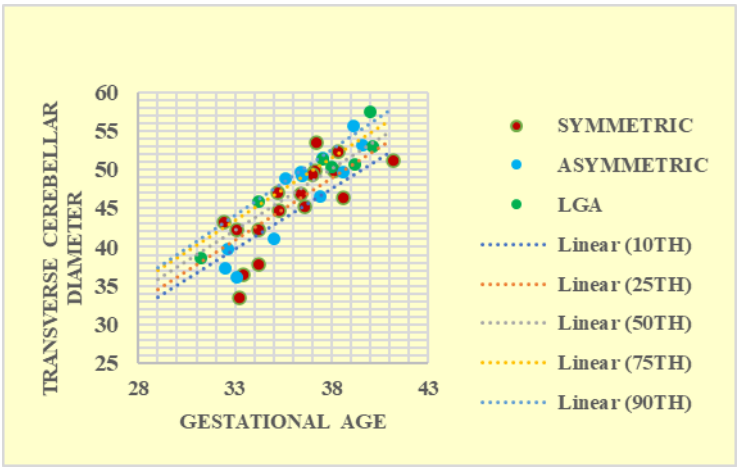


Figure 5. Normograms representation of the TCD with respect to Gestational age



LGA- large for gestation age

Figure 6. Normograms representation of the TCD with respect to Gestational age of symmetric or asymmetric IUGR

Table 5. Correlation analysis of calculated gestational age by LMP with the present and other study by TCD

BY LMP	TCD(Present study)	TCD (DAVIS et al..)
Spearman r	0.8730	0.8798
95% confidence interval	0.8185 to 0.9119	0.8279 to 0.9167
Regression equation	Gestational age=0.4052*TCD+ 16.9569	Gestational age=0.470*TCD+ 13.162
P value	<0.0001	<0.0001

Correlation analysis revealed a strong positive correlation between TCD and gestational age ($r = 0.8786$, $p < 0.0001$), weight ($r = 0.8242$, $p < 0.0001$), and length ($r = 0.8526$, $p < 0.0001$) (Table 4).

Linear regression analysis indicated a significant relationship between TCD and gestational age ($p < 0.0001$), with a regression equation of Gestational age (weeks) = 26.46 + 2.468 × TCD (cm). Linear regression analysis showed 0.4052 times change in gestational age per unit change in TCD (Figure 5 and 6).

Comparisons with other studies showed variations in TCD values across different populations (Table 5).

Discussion

The study found a strong correlation between TCD and gestational age, consistent with previous research. TCD measurements were similar to some studies but differed from others, possibly due to ethnic variations. TCD showed potential in estimating gestational age, especially in IUGR cases, but further research is needed.

The majority of 112 neonates were aged 12-24 hours (39.29%), followed by 0-12 hours (31.25%), 36-48 hours (10.71%), 60-72 hours (8.04%), 24-36 hours (7.14%), and 48-60 hours (3.5%). Equal numbers of male (50%) and female (50%) neonates were included. There was a significant difference in age but not in sex. In a study by Benavente-Fernández et.al.(12), plurality of neonates were female (51.1%).IUGR neonates exhibited significantly lower anthropometry profiles, including mean weight (2518.04±660.35 vs. 1941.55±521.00 gm) and length (47.39±4.43 vs. 45.12±4.08 cm). Additionally, non-IUGR neonates had a significantly higher mean gestational age (38.12±2.97) than IUGR neonates (35.05±2.34). Davies MW et al. study(13), documented that the mean GA was 28.9±2.8 weeks, and the birthweight averaged at 1162±397 g. Imamoglu et al.(16) observed that most were females (50.8%) while 49.2% were males.

Edward et al (17) favoured vermis measurements over the maximum transverse cerebellar width for predicting GA. Conversely, Reece et al. (10) and similar studies (14,15) found no difference in TCD between neonates with normal and restricted growth, supporting its use in predicting the gestational age. Lee et al. (18) proposed TCD as a reliable predictor under asymmetric growth restriction, but not symmetric growth restriction.

Asymmetric IUGR showed a higher mean TCD value [46.50±5.46 mm] than symmetric IUGR [45.39±5.46 mm], although the difference was not statistically significant. Chavez et al. (19) and Vinkesteijin et al. (20) found that TCD was unaffected in IUGR cases, with the former emphasizing its reliability, even in extreme growth-restricted cases. Preference for TCD over other biometric parameters stems from its resistance to disorders affecting cranial shape, growth retardation, multiple pregnancies, and large-for-date neonates. Antenatal studies by Goel et al. (21) and Dashottar et al. (22) demonstrated correlation between TCD and GA, emphasizing its precision in estimating GA, particularly in the third trimester

Overall, a substantial correlation exists between TCD and gestational age in antenatal (22-26) and postnatal (13-17) studies. In our study, the highest TCD value was observed at 40 to 41.9 weeks of gestation [53.53±1.06 mm], followed by 38 to 39.9 weeks [51.85±0.64 mm]. We observed that the TCD value increased linearly with the gestational age. Mourya et al. (25) and others (21,22) reported the same pattern.

Conclusion

TCD is a reliable parameter for assessing neonatal gestational age, particularly in uncertain cases, and can aid in differentiating types of IUGR.

Acknowledgments

None.

Conflicts of interest

There are no conflicts of interest.

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