



## Ultrasonic Estimation of the Fetal Gestational Age: Fetal Transverse Cerebellar Diameter Versus Fetal Biometry

Maha Hussein Dawod<sup>1</sup>, Haider Fa'ak Abd-El-Kareem<sup>2</sup>

### ABSTRACT:

#### BACKGROUND:

Estimation of gestational age is vital in obstetric management. Active management and delivery require knowledge of gestational age especially in high risk pregnancies, unreliable precise gestational age leads to adverse pregnancy outcome such as prematurity, low birth weight and prenatal morbidity and mortality.

#### OBJECTIVE:

To evaluate the use of the transcerebellar diameter versus conventional fetal biometry (Biparietal diameter, Femoral length, Head circumference and Abdominal circumference) for estimation of the gestational age.

#### PATIENTS AND METHODS:

Prospective observational study over one year in AL-Yarmouk Teaching hospital in department of obstetrics and Gynecology was done. One hundred pregnant women were recruited from outpatient clinic and inpatient ward from 20 weeks of gestations. The patients were divided into two groups, those who were followed till term and second group were admitting for emergency management and delivery. Two U/S exams were done for the follow up group (first group), second emergency group were examined once by U/S biometry. Post-delivery estimation of gestational age was done by a pediatrician

#### RESULTS:

The results showed Transcerebellar diameter has a high accuracy for gestational age estimation P value < 0.001 and R value = 0.994 and has superior accuracy than other fetal biometry (Biparietal diameter, Femoral length, Abdominal circumference, Head circumference).

#### CONCLUSION:

Fetal transcerebellar diameter considers the most precise tool for estimation of gestational age as revealed in this study. And as a result of high accuracy transcerebellar diameter can be used in women not sure of her date or lactating women or those with poor antenatal care. Transcerebellar diameter not affected by external factor so can be used in pregnancies that have medical conditions as fetal cerebellum not affected by these condition apart from brain anomalies.

**KEY WORD:** Transcerebellar diameter, fetal biometry, gestational age .

1M.B.Ch.B. Al Yarmouk Teaching Hospital.

2F.I.C.O.G. Consultant Obstetrician and Gynecologist Al Yarmouk Teaching Hospital

Iraq-Baghdad.

*Iraqi Postgraduate Medical Journal, 2024; Vol. 23(3): 137-146*

DOI: 10.52573/ipmj.2024.137414

Received: June 1, 2023,

Accepted: November 11, 2023



### INTRODUCTION:

Gestational age (GA) is the period that a fetus grows inside the mother's uterus. Gestational is divided into two stages: embryonic and fetal periods, embryonic period starts from conception till 10 weeks of gestation and fetal period after 10 weeks till birth. Pregnancy actually starts from the past dated or last normal menstrual period (LMP), not the conception time <sup>(1)</sup>. Accurate GA estimation is an essential part of pregnancy management and informs the obstetrician to make decisions for example:

- 1- Scheduling of woman's antenatal care <sup>(2, 3, 4)</sup>.
- 2- Planning for fetal investigation like chorionic villous sampling, amniocentesis, cordocentesis and fetal interventional therapy.
- 3- Termination of pregnancy due to complication in high risk cases like preeclampsia, intrauterine growth restriction (IUGR), gestational diabetes mellitus (GDM).
- 4- Planning for induction of labour in post date pregnancies and elective caesarean section (CS), Rh incompatibility and anti-D administration.
- 5- Administration of prophylactic corticosteroid for lung maturity and transfer to another

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

healthcare setting in cases of preterm pregnancy.

6-Classification of certain condition like hypertensive disorders in pregnancy and vaginal bleeding (abortion till 24 weeks, ante partum hemorrhage after 24weeks of gestation) and manage accordingly. Pregnancy divided into three trimesters according to gestational age: First trimester lasts till the completion of 13 weeks of gestation, Second trimester from 14 till 27 weeks of gestation, Third trimester includes 28th through 40 weeks of gestation<sup>(4)</sup>. The mean duration of pregnancy estimated by:

### 1. Last Menstrual Period (LMP):

The pregnancy median duration is 280 days (forty weeks) and LMP used for estimation date of delivery (EDD) by using Naegle's rule, this supposes that: regularly, the cycle time is 28 days. Generally, ovulation occurs on day 14th of the menstrual cycle<sup>(1)</sup>. Fertilization in the half of it <sup>(5)</sup>. The cycle is normal (i.e. not direct after stopping the oral contraceptive pills or immediately after a prior pregnancy)<sup>(1)</sup>. Patient has not ovulatory disorder like polycystic ovarian syndrome with oligomenorrhea and anovulation.

**2. Pregnancy test:** The date of first pregnancy test gives minimal GA age estimation error. The earlier the pregnancy tests the less discrepancy in gestational age estimation.

### 3. Pregnancy calendar wheels.

**4.Clinical examination:** The uterus size estimated by abdominal and examination of pelvic, is affected by factors (like fibroid), maternal obesity, multiple pregnancy, malpresentation, oligo or polyhydraminos, macrosomia, fetal growth restriction or fetal demise <sup>(1,5)</sup>. Symphysis fundal height (SFH) measurement should be recorded each antenatal visit from 24 weeks' gestation.

**5.Feeling of fetal (Quickening):** Fetal movement perception by the pregnant women is called "quickening" and it is relatively a late sign of pregnancy, usually occurring at 19-21 weeks' gestation in nulliparus women and 17-19 weeks in multiparous women.

**6. Using ultrasound (U/S):** Ultrasound is used in obstetrics as a principal imaging. Almost all pregnancies in high and middle income countries use early U/S for dating pregnancies. In 1959, The ultrasound technique uses very high frequency sound wave of between 3.5 and 7.0 MHz emitted from transducers scan. Antenatal ultrasonography determines gestational age through pregnancy in first trimester by using:

**Mean gestational sac diameter (MSD):** An intrauterine pregnancy during the first 3 to 5 menstrual weeks is determined by presence of

gestational sac<sup>(5)</sup>. The gestational sac composed from the chorionic cavity, and its echogenic rim reveal the implantation of chorionic villi and associated decidual tissue<sup>(5)</sup>.

**Crown-Rump length (CRL):** CRL measurement is representing the most precise estimation of gestational age once embryo is obviously seen; The 84 mm threshold for CRL for estimating gestational age seems reasonable. The CRL is used up to 13 weeks +6 days <sup>(5)</sup>.

**Head circumference (HC):** the HC can be measured in thalamic plane or in transventricular plane from 14 to 20 weeks of gestation <sup>(1,4,6)</sup>. The landmarks are the cavium septum pellucidum (CSP), the thalami, and the posterior lateral ventricle. Cerebellar hemispheres must not be in the imaging plane, or probe too distally giving an improper size of the fetal head<sup>(4,6)</sup>.

**Bipareital diameter (BPD):** At 20 weeks' gestation measurements of BPD with accuracy of prediction  $\pm$  (6-7) days <sup>(1)</sup>. BPD can be measured by placing the caliper in the plane of the outer edge of proximal calvarium wall and inner edge of distal calvarium wall and cerebellar hemispheres should not be in plane of image.

**Abdominal circumference (AC):** The landmarks of AC plane are the fetal stomach, the umbilical vein at the plane of portal sinus, and one entire rib should be seen <sup>(6, 7, 8)</sup>.

**Femoral length (FL):** The landmarks to measure the FL are the angles of insonation of 30 degrees, both ends of ossified diaphysis, and tissue beyond them need to be seen. FL is not affected in asymmetrical IUGR<sup>(4)</sup>. When measuring FL, the long axis of the femur must be aligned with transducer measuring only osseous portion of the diaphysis and metaphysis of the proximal femur. The proximal epiphysis cartilage (future distal femoral condyle) is not included in the FL measurement but should be visualizing assuring that femur osseous can be measured without foreshortening or elongation <sup>(4, 6,7)</sup>.

**Fetal transverse cerebellar diameter (TCD):** The development of central nerve system (CNS) from a structure called neural plate from the fifth week of gestation by thickening of the ectoderm layer. The neural plate later differentiates to form the neural tube and neural fold. In the 6<sup>th</sup> week of pregnancy, the cephalic section of neural tube transforms into three brain vesicles (forebrain), (midbrain) and (hindbrain). Ultrasonography of the fetal cerebellum can be seen as earliest as the 10<sup>th</sup>-11<sup>th</sup> weeks of gestation. The cerebellum formation is completed by the 15<sup>th</sup> week of gestation. The lower posterior surface of

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

cerebellar vermis may remain open until 17.5 weeks' gestation<sup>(9)</sup>.

The fetal cerebellar hemispheres are located in the posterior cranial fossa separated by vermis, tentorium cerebelli. The cerebellar surface contains number of fissures and folia. Differentiation of cerebellar hemispheres appear at the end of 5<sup>th</sup> week of gestation and is ended after the first year of neonatal life. Until twenty weeks of gestation, its growth is decreased after which the cerebellar hemispheres grow nearly twice in mass by end of 21 weeks of gestation. This doubling is due to growth of external granular layer and this expansion results into an increase in cerebellar diameter which is the maximum transverse diameter of the fetal cerebellum<sup>(10,11,12)</sup>. TCD is not affected by external pressure and growth deviation, thus

making it a better indicator for determination of gestational age<sup>(13)</sup>. In obstetrical imaging, the fetal TCD sometimes is used as a nontraditional biometric parameter. The measurement of the transverse cerebellar diameter in mm is relational to the "gestational age in weeks" especially between the 14-20 weeks of gestation. The TCD is not thought to be largely affected by IUGR<sup>(14)</sup>. Assessment of fetal cerebellum for gestational age has been represented since 1986, permitting estimation of gestational age irrespective of shape of fetal cranium<sup>(15)</sup>. Beside the measurement of fetal cerebellum as a tool, it has been found to have role in assessment of cases of abnormal fetal growth and cases of anomalous development of central nervous system<sup>(16,17)</sup>. The fetal TCD is measured in axial cranial imaging<sup>(18)</sup>.

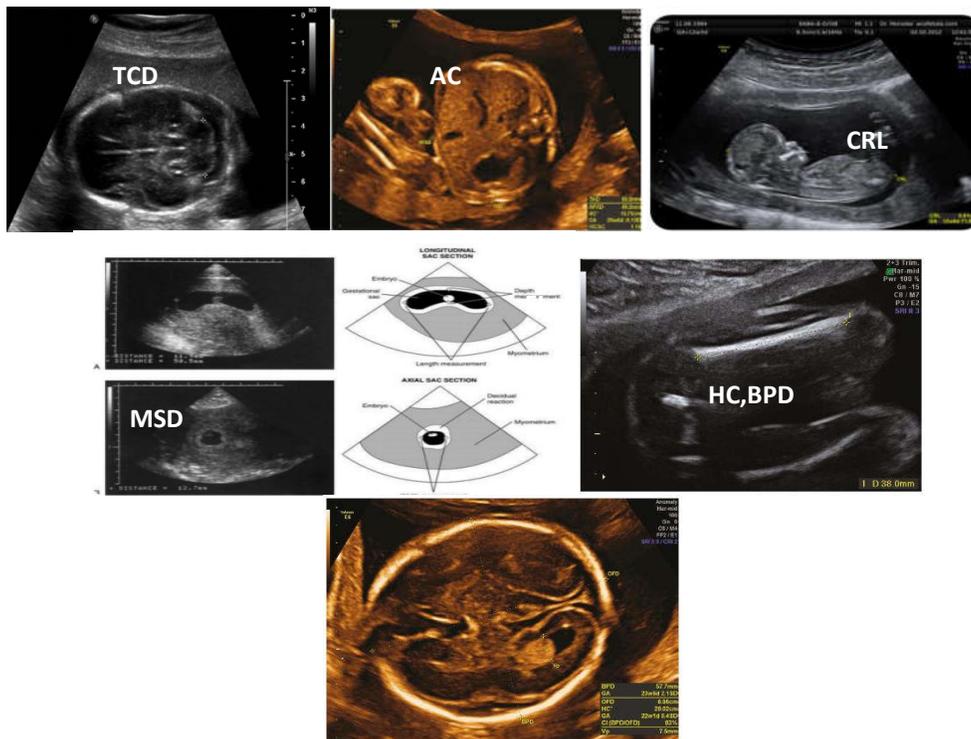


Figure 1: Ultrasound pictures of fetal biometry measurement.

**Gestational age estimation after birth evaluated by**<sup>(19)</sup>: Hair condition, Head circumference, Height, Muscular tone, Posture, Skin condition, Reflex, Vital sign and Weight.

**Newborn physical examination findings:** also help pediatrician to estimate gestational age by using the new Ballard score.

The Ballard score is depending on the neonate's physical and neuromuscular maturity and can be used up to 4 days after birth.<sup>(19)</sup>

### **AIM OF STUDY:**

To evaluate the use of transverse cerebellar diameter versus fetal biometry (BPD, FL, HC, and AC) for estimation of gestational age.

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

### PATIENTS AND METHODS:

A Prospective observational study was performed in AL-YARMUK TEACHING HOSPITAL carried out between January 2021 to December 2021 in obstetrics and gynecology department. One hundred pregnant women were recruited in outpatient clinic and inpatient ward from 20 weeks of gestations. The patients were divided into two groups, those who were followed till term and second group were admitted for emergency management and delivery. Two U/S exams were done for the follow up group (first group), second emergency group were examined once by U/S study. Post-delivery estimation of gestational age was done by a pediatrician.

#### Inclusion criteria:

- 1- Normal viable singleton pregnancies.
- 2- From 20 weeks of gestations for the first group pregnant women.
- 3- Regular cycle with known last normal menstrual history.

#### Exclusion criteria:

Irregular cycle and unknown last normal menstrual period, multiple pregnancies, congenital malformation. Clinically suspect IUGR and Medical disease (diabetes mellitus, hypertensive, and thyroid disease....etc).

Ultrasound examinations were done by a radiologist and the device used was (Samsung SIARM3HK4000057) and by using 3-5 MHz curvilinear transducer transabdominal probe. HC, BPD, AC, FL were measured.

TCD measurements were obtained by placing the sonography machines calliper at outer margins of cerebellum, at ninety degrees to the long axis of cerebellum across its widest point in suboccipitobregmatic plane of the head were thalamus, cistern magna and cavum septum pellucidum is shown. The cerebellum appeared as two lobules in the midline of posterior cranial fossa, and data recorded. Post-delivery estimation of gestational age was done by a pediatrician for both groups.

#### Statistical analysis:

The data collected were entered into Microsoft Excel sheet 2016 and loaded into SPSS-V24 statistical software. Tables and graphs were used to display descriptive statistic. Independent two sample t-test was used to find out the significance of difference between measured continuous numerical variables and Chi-square tests were used to find out significance of association between related categorical variable, P-value less than 0.05 was represent a discriminative point of significance.

#### RESULT:

One hundred pregnant women participate in this study after taking history and selected according to inclusion criteria and examination done for them. The ages of women in this study are between (15-42) years. And the gestational ages in this study are between (20-40) weeks and the mean age 28.5with standard deviation 6.9years as shown in table (1)

Table 1: The ages of the pregnant women and the gestational ages in weeks.

Variable	Max	Min	Mean	SD
Maternal age (years)	42	15	28.56	6.94
GA (weeks)	40.4	20.1	34.20	4.80

Age distribution in this study divided in group's ≤ 20 years14%, 21-30 years46%, ≥ 30years40% of participating women in this study as shown in figure (2).

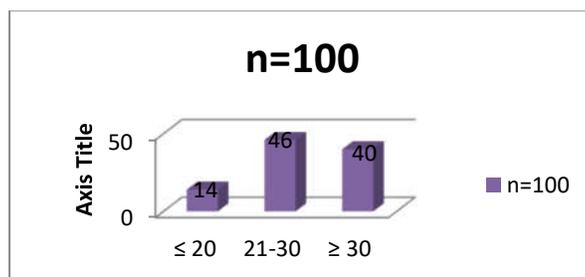
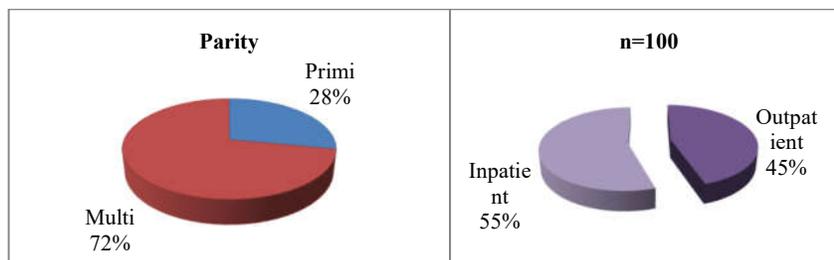


Figure 2: Age distribution of pregnant women in this study.

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

From hundred pregnant women, 79 of them have one visit and 21 of them have two visits for measurement GA as illustrated in figure

(16). According to the parity 72% multigravida and 28% primigravida participate in this study as shown in figure (3).



**Figure 3: Distribution of pregnant women according to parity and distribution of pregnant women according to the state of patient.**

Fifty-five percent of participating pregnant women were admitted to our hospital as emergency cases. Forty-five percent of participating women were seeking outpatient clinic. As shown in figure (18). From the one hundred normal women with regular cycle GA calculated using Naegle's rule and fetal biometry

BPD, HC, AC, FL were measured by radiologist, GA by LMP compared with BPD, FL, AC, HC by using student t-test, p-value and correlation analysis. The correlation coefficient between GA by LMP and GA measured by fetal biometry (BPD, HC, AC, FL, TCD) for 100 patient 1st visit shown in table (2).

**Table 2: The correlation coefficient of gestational age (by LMP) and estimation gestational age based on fetal biometry for 100 patients (1<sup>st</sup> visit).**

Parameter	P value	R value
GA versus BPD	< 0.001	0.969
GA versus FL	< 0.001	0.983
GA versus HC	< 0.001	0.989
GA versus AC	< 0.001	0.987
GA versus TCD	< 0.001	0.994

In TCD the standard deviation and mean for each week revealed that TCD in mm represent to weeks of gestation. Correlation coefficient between GA

and TCD 0.994 and significant p-value less than (0.001) which is highly significant, as shown in table (3).

**Table 3: The person correlation coefficients between GA by LMP and TCD.**

One-Sample Test (88 patients)						
Test Value = 0						
	T	R value	P value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
GA2	114.973	0.907	0.09	36.42841	35.7987	37.0582
GAPed	138.718			35.19318	35.5821	36.8043

The correlation coefficient between GA by measured by TCD and GA measured by fetal

biometry (BPD, HC, AC and FL) for 100 patients for 1st visit is shown in table (4).

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

**Table 4: The correlation coefficient between TCD versus fetal biometry for 100 patients for 1<sup>st</sup> visit.**

Parameter	P value	R value
TCD versus BPD	< 0.001	0.972
TCD versus FL	< 0.001	0.987
TCD versus HC	< 0.001	0.990
TCD versus AC	< 0.001	0.990
TCD versus GA by LMP	< 0.001	0.994

**Table 5: Correlation coefficient between TCD versus fetal biometry for 21 patients for 2nd visit (follow up group).**

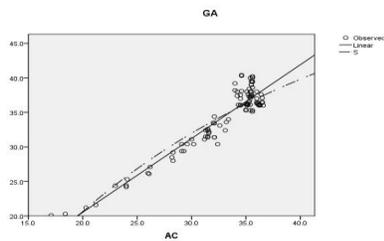
Parameter	P value	R value
TCD versus BPD	< 0.001	0.988
TCD versus FL	< 0.001	0.993
TCD versus HC	< 0.001	0.975
TCD versus AC	< 0.001	0.968
TCD versus GA by LMP	< 0.001	0.996

From 100 pregnant women in this study 88 women estimation of GA post-delivery done by a pediatrician, 12 of pregnant women skipped the examination. GA was estimated by a pediatrician and compared with GA by LMP. The p- value of this correlation is 0.09 so it's not significant, as shown in table (6).

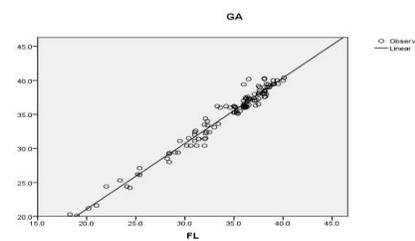
**Table 6: Person correlation coefficients between estimated GA by LMP and estimated by a Pediatrician.**

One-Sample Test (88 patients)						
Test Value = 0						
	T	R value	P value	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
GA2	114.973	0.907	0.09	36.42841	35.7987	37.0582
GAPed	138.718			35.19318	35.5821	36.8043

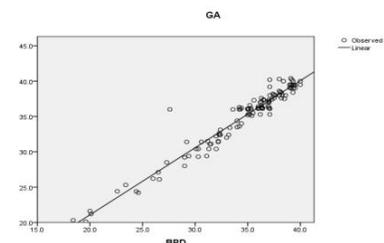
The Scatter graph GA by LMP versus BPD, FL, HC, AC and TCD show linear curvilinear relationship, as shown in figure (4, 5,6,7,8).



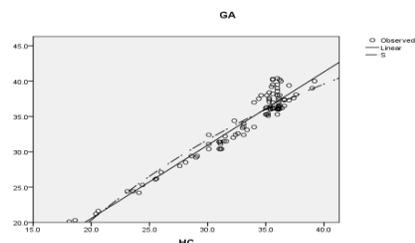
**Figure 4**



**Figure 5**



**Figure 6**



**Figure 7**

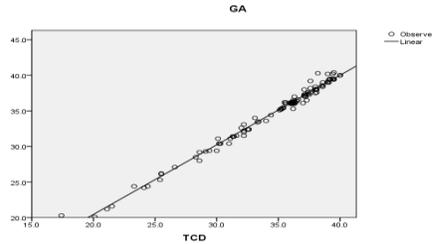


Figure 8

**DISCUSSION:**

Estimation of gestational age accurately is necessary for the planning management in obstetric<sup>(20)</sup>. The first use of diagnostic ultrasonography done by professor Ian Donald of Glasgow and the two-dimension ultrasound discovered in 1958 by Mac Vicar and Brown<sup>(25)</sup>. Knowing the LMP corresponds well to GA, but it's not useful when women does not know her LMP. The fetal biometry used to estimate gestational age by measuring BPD, FL, AC, HC<sup>(26,22)</sup>, each of these parameters has its advantages and restrictions. There's newer parameters discovered and has its own efficiency like TCD, fetal kidney length, Humerus length, prenasal skin thickness, intraocular distance, three dimensional fractional limb volume, nasal bone length, foot length, hand length etc.<sup>(23,25)</sup>. Error in the gestational age estimation leads to prematurity and post maturity and its corresponding infant morbidity and mortality<sup>(26)</sup>. The cerebellum (Latin for "little brain") in human is smaller than cerebrum but has a vital role in motor control and cognitive function and language and emotional control<sup>(27,28)</sup>. The cerebellum begins to develop earlier in neural system and last one to complete after birth and represent the most complex structure of embryo<sup>(29)</sup>. Fetal transcerebellar diameter not affected by external pressure like BPD such as breech presentation and oligohydraminos which may induce pressure on fetal head, so TCD useful in estimation of gestational age in growth restriction and macrosomia<sup>(30)</sup>. The presence of dense petrous temporal bones and posterior cranial fossa that surround fetal cerebellum make the fetal bones less affected by external compression, so TCD is useful even in twin and growth restricted fetuses<sup>(31,32)</sup>. In this prospective, observational study along 12 months include one hundred pregnant women of age 15-42 years and gestational age from 20-40 weeks were fetal biometry (BPD, HC, FL and AC) measured beside TCD. The variability of each parameter corresponds to gestational age as pregnancy advances. The study revealed there's

significant correlation coefficient between GA measured by LMP versus BPD p value < 0.001 and R value =0.969. GA measure by LMP versus H.C. P value < 0.001 and R value =0.989. GA measured by LMP versus FL p value < 0.001 and R value=0.983. GA measure by LMP versus A.C. p value< 0.001 and R value= 0.986. The present study showed good correlation coefficient between TCD and others fetal biometry i.e. TCD versus BPD P value < 0.001 and R value =0.972.TCD versus FL p value < 0.001 and R value =0.987, TCD versus H.C. p value < 0.001 and R value =0.990, TCD versus A.C. P value < 0.001 and R value 0.990. In our study Pearson correlation coefficient between GA by LMP and estimation of gestational age by a pediatrician post-delivery in follow up group showed insignificant relationship value 0.09 and R value =0.907. These finding are in agreement with those obtained by Ahmed MA et al. who evaluate the role of fetal transcerebellar diameter in prediction of gestational age in second and third trimester of pregnancy at (2014), his study revealed TCD measurement accurate to measure gestational age especially in third trimester and recommend to use it as a biometric parameter<sup>32</sup>.A study obtained by Gaurav Sharma et al (2015) when retrospective study for 100 women from 12-40 weeks of gestation when morphology of cerebellum was studied and measurement of TCD/AC found significant linear relationship between TCD and with TCD/AC remain constant throughout gestation and can be used for fetal growth monitoring<sup>33</sup>. A study done by Ravindernath et al at (2017) showed correlation between TCD and other fetal parameters and consider TCD a good parameter in case of skull abnormalities<sup>(35)</sup>.The current results are in line with those of study done by Patile et al at (2018) considering The TCD which can be used as a new tool for estimation of gestational age<sup>35</sup>. Also our analysis is further support the idea of a study done by Alsaied Abdelmaksod et al at (2018). They conclude when measuring TCD, BPD, FL for 200

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

pregnant women in the third trimester, that the TCD is the most accurate one followed by FL and then BPD<sup>36</sup>. Another study done by Hanna et al at (2019) found the strong relationship between TCD and gestational age by LMP they consider TCD a good predictor for gestational age when compared to other biometry especially between 14-22 weeks<sup>37</sup>. Hussein KA et al at (2019) in a prospective study of 200 patients at the gestational age 14-40 weeks with measurement of TCD/AC and TCD/FL, TCD revealed highest relationship with gestational age as pregnancy advance, and ratio of TCD/FL and TCD/AC can be used as a predictor parameter in IUGR with cut off value of mean  $\pm$ SD (15.49), (72.588)<sup>38</sup>. We observe in this study that there's insignificant relationship between gestational age by LMP and the estimation of gestational age by a pediatrician with p value= 0.09, this may be because neonatal care unit in our hospital have many doctors with short course training only two months and exchange by another doctors, so the estimation of gestational age was not done by the same pediatrician.

### CONCLUSION:

In our prospective study of one hundred pregnant women over 12 months, we concluded that the TCD measurement in millimeter shows a strong correlation with GA in weeks by LMP and BPD, FL, AC and HC. In our study we found TCD measurement is the most accurate parameter for estimation of gestational age than BPD, FL, AC and HC and there's linear relationship from 20 - 40 weeks of gestation. The TCD measurement in millimeter is equal to weeks of gestation. TCD measurement is not affected by shape of skull of the baby. Accuracy of TCD measurement in estimation of gestational age is not affected as pregnancy advance. Many pregnant women in IRAQ, because of the socioeconomic limitation or if they were descending from rural areas have the first antenatal visit either in third trimester or at delivery or when they have emergency accident during their pregnancy. Poor education and being lactating with short parity spacing without antenatal care or early ultrasound which makes obstetricians face difficulty in calculation of gestational age and pregnancy management. Conventional fetal biometry decrease in accuracy in some condition may have their limitation for many causes, IUGR, congenital anomaly, fetal presentation etc... So we need a new dependable parameter to resolve this problem, and TCD help obstetricians in such conditions.

### Recommendation:

Obstetrician can use transverse cerebellar diameter (TCD) as a predictive tool for

estimation of gestational age in addition to other parameter from 20-40 weeks as revealed in our study. TCD can be used in cases of women not know of her LMP because of high accuracy that not affected by factors that make other parameter less reliable.

### REFERENCES:

1. KENNY, Louise C.; MCCARTHY, Fergus (ed.). *Obstetrics by ten teachers*. CRC Press, 2024.
2. Cunningham, Kenneth J. Leveno, et.al. Williams OBSTETRICS 24TH EDITION. Copyright © 2014 by McGraw-Hill Education. print version: ISBN: 978-0-07-179893-8, MHID: 0-07-179893-5.
3. Gupta, Sonika .VIKrant Gupta et al.transcerebellar diameter as parameter for determination of gestional age ,international Journal of scientific research.2019;8-12\print issueNO.2277-8179/DOI:10.36106\ijsr.
4. DUTTA, D. C. *DC Dutta's textbook of obstetrics*. JP Medical Ltd, 2015.
5. medline plus medical encyclopedia .gestional age.reviewed October 2,2019
6. Kurjak, Asim, Frank A Chervenak , Donald School Textbook of Ultrasound in Obstetrics and Gynecology. © Digital Version 2018, Jaypee Brothers Medical Publishers. ISBN 978-93-86056-87-0
7. MURTHY, BS Rama. *Imaging of Fetal Brain and Spine: An Atlas and Guide*. Springer, 2019.CallenPW,Ultrasonography in obstetric and gynecology .Elisever Health Science .6<sup>th</sup> edition (2016) ISBN:1455726745.
8. CallenPW,Ultrasonography in obstetric and gynecology .Elisever Health Science .6<sup>th</sup> edition (2016) ISBN:1455726745.
9. GÖYNÜMER, Fikret Gökhan, et al. Nomogram of fetal transcerebellar diameter at 16–24th gestational weeks. *J Turkish-German Gynecol Assoc*, 2009;10:21-25.
10. VENI, S. Krishna; SUGAVASI, Raju; DEVI, V. Subhadra. Histogenesis of human foetal cerebellar cortex. *Anatomy Journal of Africa*, 2015; 4.2: 598-603.
11. NOWAKOWSKA-KOTAS, Marta; KĘDZIA, Alicja; DUDEK, Krzysztof. Development of external surfaces of human cerebellar lobes in the fetal period. *The Cerebellum*, 2014;13:541-48.
12. SCOTT, Julia A., et al. 3D morphometric analysis of human fetal cerebellar

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

- development. *The Cerebellum*, 2012;11:761-70.
13. Hasimito K,T,Shimoya K,kanzakiT,Clopp JF,MuarataY.Fetal cerebellar:US appearance with advancing gestational age. *Radiology*.2018;22170-74.
  14. Rodechk CH,Whittle MJ.Fetal medicine,basic science and clinical practice.Elsevier Health Science (2018 )ISBN:0443104085.
  15. SHERER, D. M., et al. Nomograms of the axial fetal cerebellar hemisphere circumference and area throughout gestation. *Ultrasound in obstetrics & gynecology: the official journal of the International Society of Ultrasound in Obstetrics and Gynecology*, 2007, 29.1: 32-37.
  16. ROY, Joydeep, et al. Role of the Ratio of Trans Cerebellar Diameter and Abdominal Circumference in Detecting Asymmetrical Intra Uterine Growth Restriction. *Journal of Evolution of Medical and Dental Sciences*, 2019;23.30: 3858-63.
  17. GALLERY, Visit Voluson. ISUOG Practice Guidelines (updated): sonographic examination of the fetal central nervous system. Part 1: performance of screening examination and indications for targeted neurosonography. *Ultrasound Obstet Gynecol*, 2020;56:476-84.
  18. SERSAM, Lilyan W.; FINDAKLY, Sura Basil; FLEEH, Najlaa Hanoon. Fetal transcerebellar diameter in estimating gestational age in third trimester of pregnancy. *Journal of Research in Medical and Dental Science*, 2019; 7.5:60-66.
  19. Arcangela Lattari Balest , MD, University of Pittsburgh, School of MedicineLast full review/ revision Apr 2021. MSD manual professional version. <https://www.msmanuals.com/professional/pediatrics/perinatal-problems/gestational-age>.
  20. NAGESH, R.; SEETHA PRAMILA, V. V.; SHUKLA, Anil Kumar. Transverse cerebellar diameter—an ultrasonographic parameter for estimation of fetal gestational age. *Int J Contemp Med Res*, 2016, 3.4: 1029-31.
  21. MANDAL, Sumanta Kumar, et al. Evaluation of fetal transcerebellar diameter as a sonological parameter for the estimation of fetal gestational age in comparison to biparietal diameter and femur length. *age*, 2019;6:7.
  22. GEORGE, Rintu, et al. Can trans-cerebellar diameter supersede other fetal biometry in measuring gestational age? A prospective study. *Egyptian Journal of Radiology and Nuclear Medicine*, 2021;52:1-6.
  23. SHAN, B. Priestly; MADHESWARAN, M. Revised estimates of ultrasonographic markers for gestational age assessment of singleton pregnancies among Indian population. *International journal of advanced science and technology*, 2010;17:1-12.
  24. ABONYI, Everistus Obinna, et al. Sonographic estimation of gestational age from 20 to 40 weeks by fetal kidney lengths' measurements among pregnant women in Portharcourt, Nigeria. *BMC Medical Imaging*, 2019;19:1-7.
  25. TIRUNEH, Chalachew. Estimation of gestational age using neonatal anatomical anthropometric parameters in Dessie Referral Hospital, Northeast Ethiopia. *Risk Management and Healthcare Policy*, 2020:3021-29.
  26. MANDAL, Sumanta Kumar, et al. Evaluation of fetal transcerebellar diameter as a sonological parameter for the estimation of fetal gestational age in comparison to biparietal diameter and femur length. *age*, 2019;6:7.
  27. HODOS, William. Evolution of cerebellum. *Encyclopedia of neuroscience*, 2009:1240-43.
  28. WOLF, Uri; RAPOPORT, Mark J.; SCHWEIZER, Tom A. Evaluating the affective component of the cerebellar cognitive affective syndrome. *The Journal of neuropsychiatry and clinical neurosciences*, 2009; 21.3: 245-53.
  29. HAINES, Duane E.; DIETRICH, Espen. The cerebellum—structure and connections. *Handbook of clinical neurology*, 2012;103:3-36.
  30. BANSAL, Mukesh, et al. A study of correlation of transverse cerebellar diameter with gestational age in the normal & growth restricted fetuses in Western Uttar Pradesh. *PJSR*, 2014;7.2:16-21.
  31. VEDPATHAK, Shashank; JADHAV, Dhanaji; BELSARE, Swati. Ultrasonographic study of transverse diameter of fetal cerebellum and length of femur as markers for accurate estimation of gestational age. *International Journal of Anatomy and Research*, 2020;8.1.3: 7360-66.

## ULTRASONIC ESTIMATION FETAL GESTATIONAL AGE

32. DASHOTTAR, Sunita, et al. Transcerebellar diameter: an effective tool in predicting gestational age in normal and IUGR pregnancy. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*, 2018;7.10: 4190-97.
33. AHMED, Mohamed AS. Accuracy of fetal transcerebellar diameter nomogram in the prediction of gestational age in singleton gestation at the second and the third trimesters of singleton pregnancy. *Journal of Evidence-Based Women's Health Journal Society*, 2014;4.4:184-88.
34. SHARMA, Gaurav; GHODE, Rita. Fetal transcerebellar diameter and transcerebellar diameter--abdominal circumference ratio as a menstrual age independent parameter for gestational age estimation with grading of cerebellar maturity. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*, 2015; 4.6: 2036-41.
35. RAVINDERNATH, M.; REDDY, Mahender; REDDY, Nihar. Accuracy of transverse cerebellar diameter measurement by ultrasonography in the evaluation of fetal age. *Int J Adv Med*, 2017; 4.3: 836-41.
36. PATIL, S.; PATIL, M.; GAIKWAD, Swati. Transverse cerebellar diameter—an ultrasonographic parameter for estimation of gestational age and grading of fetal cerebellar growth. *Int J Anat Res*, 2018, 6.1: 4947-4950. Alsaied Abdelmaksod Askr, Mahmoud Salah Mahmoud, et al Comparison between Taans Cerebellar Diameter, Biparietal Diameter and Femur Length for Gestational Age Measurement Accuracy in The 3rd Trimester. *The Egyptian Journal of Hospital Medicine* 2018;73:7300-5.
37. ASKR, Alsaied Abdelmaksod; MAHMOUD, Mahmoud Salah; SALLOUM, Asmaa Ahmed Mahmoud. Comparison between taans cerebellar diameter, biparietal diameter and femur length for gestational age measurement accuracy in the 3rd trimester. *The Egyptian Journal of Hospital Medicine*, 2019; 74.1:87-93.
38. EL-EBEISY, Hanna Abd-Elhammed; MOHAMMED, Hanan Abd-Elmonem; MOHAMMED, Basma Osman. Accuracy of fetal transcerebellar diameter in the prediction of gestational age in singleton pregnancy at the second and the third trimesters. *The Egyptian Journal of Hospital Medicine*, 2019;77.1:4714-19.
39. HUSSAIN, Karumanchi Ashok, et al. Fetal transcerebellar diameter to abdominal circumference ratio (TCD/AC) and to femur length ratio (TCD/FL) in the assessment of normal fetal growth. *Journal of Dr. NTR University of Health Sciences*, 2019;8.1:5-10.