Reliability of two dimensions measurement of fetal thalamus as fetal growth parameter, using ultrasound of fetal brain

Fiabilidad de la medición en dos dimensiones del tálamo fetal como parámetro de crecimiento fetal, utilizando ultrasonido del cerebro fetal

Rana T. Mehsen. https://orcid.org/0000-0001-5072-1760
[1]Lecturer, college of medicine, Jabir Ibn Hayan medical university collag IRAQ/al-Najaf.
Email: r.tahseen@jmu.edu.iq.
Received/Recibido: 05/12/2020 Accepted/Aceptado: 06/15/2020 Published/Publicado: 07/20/2020

Abstract

Introduction: The ultrasound is considered very important part to evaluate and measure the fetal growth and fetal biometry. It is important in all pregnancies to measure fetal biometry and gestational age, biparietal diameter (BPD) and femur length (FL) is precise fetal biometrics measurements commonly doing in 2nd and 3rd trimester. Correct age of fetus is essential for suitable antennal attention, the aim of study is to show the reliability of summation 2-dimension thalamic size for estimation the fetus's age by using US and compare it with other tools of fetal age measurements like BPD and FL and LMP.

Method: This is retrospective study conducted at Al Zahraa teaching maternity and pediatrics hospital at Al-najaf /Iraq, from period between march 2018-september 2019, using GE S6 Ultrasound machine. Antenatal us US examination done for 99 uncomplicated pregnant women during their routine antenatal visit.

Results: A random sample of 99 pregnant female from different trimesters of pregnancy that included in current study, there is no differences and strong positive correlation between ages of fetuses measured by summation of 2 dimension fetal thalamus and fetal age measured by biparietal diameter (BPD), femur length (FL) and age measured by last menstrual cycle (LMP), P-value<0.05, also there is strong positive correlation between 2 dimension fetal thalamus (height to width) and ages of fetuses measured by summation of 2 dimension of fetal thalamus.

Conclusion: we can use summation of 2-dimension fetal thalamus to detect the fetal age as a growth parameter.

Keywords: antenatal ultrasound, fetal thalamus, fetal growth parameter, LMP, BPD, FL.

Resumen

Introducción: la ecografía se considera una parte muy importante para evaluar y medir el crecimiento fetal y la biometría fetal. Es importante en todos los embarazos medir la biometría fetal y la edad gestacional, el diámetro biparietal (DBP) y la longitud del fémur (FL) son medidas precisas de biometría fetal que se realizan comúnmente en el segundo y tercer trimestre. La edad correcta del feto es esencial para una atención antenal adecuada, el objetivo del estudio es mostrar la fiabilidad del tamaño talámico sumatorio de 2 dimensiones para estimar la edad del feto mediante el uso de EE. UU. Y compararlo con otras herramientas de medición de la edad fetal como BPD y FL y LMP.

Método: Este es un estudio retrospectivo realizado en el hospital de enseñanza de maternidad y pediatría de Al Zahraa en Al-najaf/Iraq, desde el período comprendido entre marzo de 2018 y septiembre de 2019, utilizando la máquina de ultrasonido GE S6. Examen prenatal con nosotros realizado para 99 mujeres embarazadas sin complicaciones durante su visita prenatal de rutina.

Resultados: una muestra aleatoria de 99 mujeres embarazadas de diferentes trimestres del embarazo que se incluyeron en el estudio actual, no hay diferencias y una fuerte correlación positiva entre las edades de los fetos medidas por la suma del tálamo fetal de 2 dimensiones y la edad fetal medida por el diámetro biparietal (DBP), longitud del fémur (FL) y edad medida por el último ciclo menstrual (LMP), valor P<0.05, también hay una fuerte correlación positiva entre el tálamo fetal de 2 dimensiones (altura a anchura) y las edades de los fetos medidas por la suma de 2 dimensiones de tálamo fetal.

Conclusión: podemos usar la suma del tálamo fetal de 2 dimensiones para detectar la edad fetal como parámetro de crecimiento.

Palabras clave: ultrasonido prenatal, tálamo fetal, parámetro de crecimiento fetal, LMP, DBP, FL

Introduction

Diagnostic ultrasound is considered a very important tool to assess fetal gestational age and measuring fetal biometry. Correct fetal age is essential for suitable antennal care[1]. Routinely, the radiologists measure the femoral length, biparietal diameter, abdominal and head circumference for determine the gestational age and date of delivery[2]. Biparietal diameter (BPD) plus femur length (FL) are most commonly used fetal biometrics measurements in 2nd and 3rd trimester for assessing fetal gestational age[3]. Biparietal diameter is ahead transverse width so it is distance between inner and outer edge of the parietal bone, it is appropriate to use afterward 12 weeks[4], BPD is important measurement of many of them taking within pregnancy, and it use for evaluation of fetal weight and gestational age. (¿?) Most females have at least one to three US during their pregnancy, at 20 weeks of gestation any females at risk must do more US[5]. BPD doing in late pregnancy have no benefit for determine the accurate fetal age[6], so more accurate BPD is between 12 to 26 weeks of gestation, and some studies showed that BPD become less effective in estimation fetal age after 20 weeks[7]. Femoral length is depending on skeletal dysplasia, the most common apply after 14 weeks[8]. (reference 8 does not support this concept) FL is measure the length of femoral bone of fetus and represented the longitudinal growing of the fetus, it increases from 1.5 cm at 14 weeks of gestation to 7.8 cm at term[9].

Thalamus considered the main structure of diencephalon, it is a sensory and motor communicate midpoint with widespread networks to the cortex, sub cortex, and cerebellum, thalamus variation in size as the brain become develops according to ages of fetus, the increasing in size occur between of 20 to 43 weeks of gestation[10]. Also thalamus before this age it tends to be decrease in volumes (at age 4 to 18 weeks) when regulatory for cranial size[11,12]. Any damage to thalamus can produce behavioral and sensory and motor syndromes that affecting orientation, knowledge, memory, speech, painful, and movement[13,14]. Any decrease in thalamic size may lead to psychiatric problems and autism[15].

The aim of current study is to show the validity and difference between 2-dimension thalamic size for estimation the fetuses age by using US and compare it with other tools of fetal age measurements like BPD and FL and LMP.

Patient & methods: This is retrospective study conducted at Al –Zahraa teaching maternity and pediatrics hospital in Al-Najaf /Iraq, for period between March 2018-november 2019, using GE S6 Ultrasound machine. Antenatal us examination done for 99 uncomplicated pregnancy pregnancies during their routine antenatal visit

Exclusion criteria:

1. Known case of D.M, or hypertension.

2. Fetal head, CNS or MSK anomalies.

3. suspected IUGR

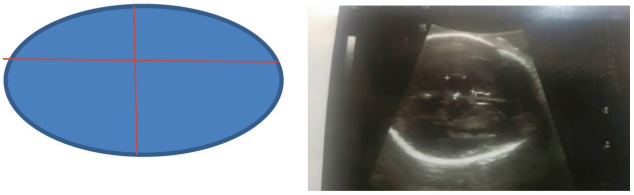
4. Unknown LMP

5. When Fetal position is suboptimal impeding clear measurement

The FL in measured from both metaphyseal ends.

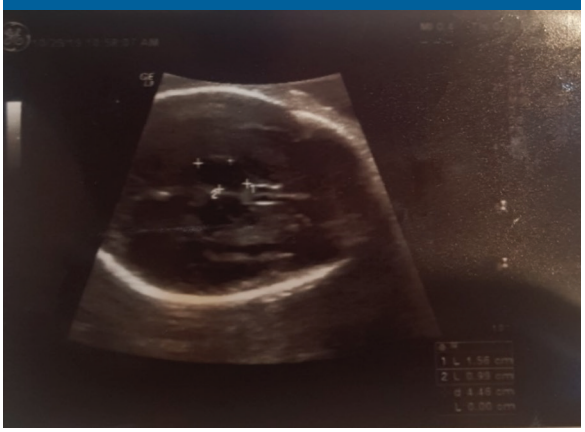
Trans-axial plane of fetal brain is obtained at thalamic level; the BPD is measured using Hadlok measuring from outer to inner table. Then the image is zoomed foe butter delineation of Fetal thalamus which identified as bilateral symmetrical, oval shape, hypo echoic structure and its measurement is obtained, the 2d axial dimension in measured (including length(L) & width (W)in mm.

Figure 1: A schematic drawing, B: US imaging, for measuring thalamus length & width



The L in (mm) is added to W (in mm) the result then represents the GA, the constant number summation will represent gestational age in weeks and any number after comma will represent gestational age by days L+W=GA in weeks +days. And for statistical purposes we multiply number of weeks by 7 for assessing it in days.

Figure 2: example of calculation formula



This US picture of 26weeks pregnant lady calculated by LMP, thalamic measurement was found to be: L=15.6mm, W=9.6mm GA by weeks =15.6+9.6= 25weeks+5d25x7=175 d+5d= 180days

Statistical analysis done by SPSS 22 using mean and SD for fetuses age for all measurements tools with min. and max. Ages. Also used (Mann-Whitney) Z test for continu-

ous data and not normally distribution for show the differences between measurement s tools, also used spearman correlation for continuous data to show the correlation between height to width (2 dimension) of thalamus and 2-dimension thalamic size.

A random sample of 99 pregnant female from different trimesters of pregnancy that included in current study, the mean age of fetuses by LMP (228.4±43.64) days with min age 107 days and max age 287 days, while the mean age of fetuses when take BPD was (226.86±43.2) days with min age 110 days and max age 283 days, the mean age of fetuses when take FL was (227.52±43.4) days with min age 101 days and max age 288 days, and finally the mean age of fetuses when take 2 dimension thalamic size was (227.04±45.14) days with min age 92 days and max age 294 days, as show in table 1.

Table 1: mean and SD with min. and max ages of fetuses by days when measured by LMP, BPD, FL and 2-dimension thalamic size.

Ages in days	Mean ± SD (days)	Min. age (days)	Max. age (days)
Age by LMP	228.4 ± 43.64	107	287
Age by BPD	226.86 ± 43.2	110	283
Age by FL	227.52 ± 43.4	101	288
Age by 2 dimension thalamic size	227.04 ± 45.14	92	294

According to table 2, the difference between ages of fetus when measured by LMP, BPD, FL and 2 dimension thalamic size, there is no significant difference between ages when measured by LMP and BPD, FL and 2 dimension thalamic size P-values (0.69,0.81,0.82) respectively, also there was no difference between ages when measured by BPD and FL, 2 dimension thalamic size P-values were (0.9, 0.91) and finally there was no difference between ages when measured by FL and 2 dimension thalamic size P-value was (0.94).

Table 2: difference between measurements of fetus ages (LMP, BPD, FL and 2-dimension thalamic size).

Difference between:	Mean ± SD (days)	Z	P-value
1) Age by BPD	226.86 ± 43.2	0.4	0.69
Age by LMP	228.4 ± 43.64		
2) Age by FL	227.52 ± 43.4	0.24	0.81
Age by LMP	228.4 ± 43.64		
3) Age by 2 dimension thalamic size	227.04 ± 45.14	0.23	0.82
Age by LMP	228.4 ± 43.64		
4) Age by FL	227.52 ± 43.4	0.13	0.9
Age by BPD	226.86 ± 43.2		
5) Age by 2 dimension thalamic size	227.04 ± 45.14	0.11	0.91
Age by BPD	226.86 ± 43.2		
6) Age by 2 dimension thalamic size	227.04 ± 45.14	0.7	0.94
Age by FL	227.52 ± 43.4		

(Mann-Whitney) Z test, more than 0.05 (not significant).

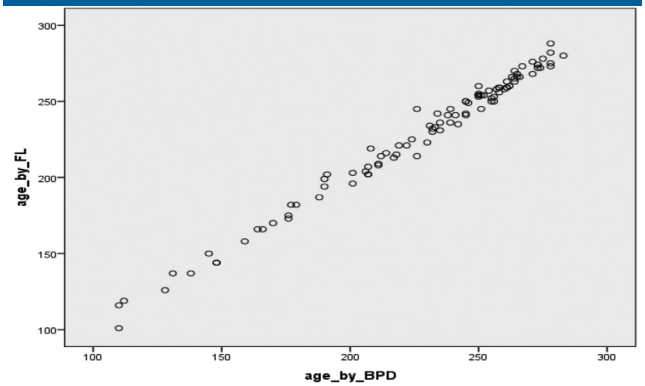
From table 3 there is positive correlation between ages of fetuses measurred by LMP and BPD and FL P-value <0.05, mean when increase in age of fetuses measurd by LMP so lead to increas fetuse ages measurred by BPD and FL. Also there is positive correlation between age of fetuses measirred by 2-dimension thalamic size and LMP, BPD and FL (P-value <0.05).

Table 3: colleration between ages measurred by (LMP, BPD, FL and 2-dimension thalamic size).

Correlation	Age by LMP (R)	P-value
Age by BPD	0.985	0.0001
Age by FL	0.985	0.0001
Correlation	Age by 2 dimension thalamic size (R)	
Age by BPD	0.947	0.0001
Age by FL	0.953	0.0001
Age by LMP	0.955	0.0001

Spearman correlation, < .05 (significant).

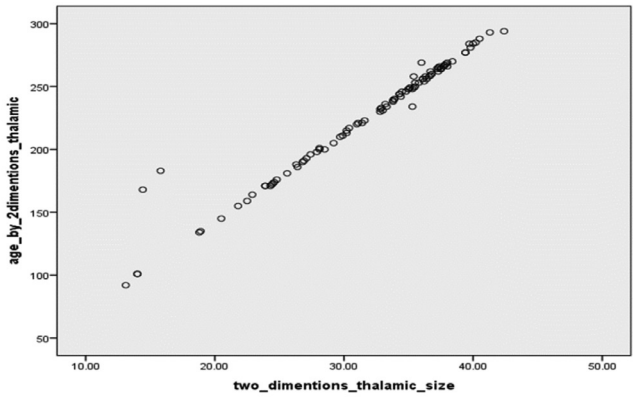
From figure 3 there is positive correlation between ages of fetuses measured by FL and BPD



R= 0.989, P-value = 0.0001

There is positive significant correlation between height to width (2-dimension) of thalamus and 2-dimension thalamic size, so when increase in age of fetus lead to increase in 2-dimension height to width of thalamus. The mean and SD of height to width (2 dimension) of thalamus =1.9±6.78 mm. as shown in fig 4.

Fig 4: correlation between height to width (2 dimension) of thalamus and 2-dimension thalamic size



Correlation Coefficient = 0.99**, P-value= 0.0001**(positive correlation).

Discussion

Thalamic gland is vital brain neural construction, it ascends from diencephalon, at fifth week of fetal age the thalamus and hypothalamus are noticeable as bulges on the inner part of the diencephalic neural channel. Then at seventh week and later the thalamus develops excessively and appear the major component in the diencephalon. So due to this high development action, the thalamus progressively swells into the diencephalic lumen, and decreasing it to a slim cleft, and right plus left sides anger in the midline, and produce 'massa intermedia' or 'interthalamic Conexus'[16-18].

Thalamus best to be visualized at mid-trimester ultrasound as bilateral medium echogensity Para central ovoid structure. The size of thalamus continues to increase relative to gestation age Our study is a new technique for estimation of gelation age the fore we didn't found a previous study for measuring the thalamus as growth parameter, although a few studies mention thalamic growth in relation to gestational age[10]. Also In 2015 Yang R[1] et. Conclude that al Ultrasonic measurement of diameter of fetal thalamus caudate nucleus, and lenticular nucleus through thalamic transverse section is simple and convenient. And measurements increase with fetal gestational weeks and there is linear regression relationship between them[19].

In current study we describe the significant rise in the thalamus AP dimension and age of fetuses, so in our study we found that thalamic 2-dimension size by used US can measured fetus age as similar as BPD and FL measurements. In the current study the mean and SD of fetuses ages that measured by LMP was 228.4±43.64, this mean all fetuses ages by used LMP measurement was 33.3±7 weeks. Also in our study the mean and SD of fetuses ages that measured by BPD was 226.86±43.2, this mean all fetuses ages by used BPD measurement was 33.3±6.2 weeks. Also the mean and SD of fetuses ages that measured by FL was 227.52±43.4, this mean all fetuses ages by used FL measurement was 33.2±6.5 weeks. While the mean and SD of fetuses ages that measured by 2-dimension thalamic size was 227.04±45.14, this mean all fetuses ages by used 2-dimension thalamic size measurement was 32.5±6.5 weeks.

This small variation of SD of 2d thalamic measurement in comparison to FL& BPD may attributed to moderate interobserver repeatability due to the similar echogenicity between the thalamus and its surrounding structures as in studies done before[10,19-21].

When compared the age of fetuses that measured by LMP and then do US and measured the age of fetuses by BPD measurement, in our study there was no difference between this 2 measurements (P-value >0.05) and the age of fetuses as same, also in our study there was no difference between age of fetuses measured by LMP and FL (P-value >0.05) the same age by to measurements, there was positive correlation between ages measured by LMP and fetuses age measured by BPD (R=0.985) and there was positive significant correlation between ages measured by LMP and that measured by FL (R=0.985). this results agreed with results done by Muralidhar et al. that stated there was significant correlation between ages measured by LMP and BPD in 2nd and 3rd trimester of pregnancy (R=0.862) and positive significant correlation between ages measured by LMP and BPD in 2nd and 3rd trimester of pregnancy (R=0.887) and FL is better parameters to measure fetal age in 2nd and 3rd trimesters[22-24].

In our study like many studies there was no differences (>0.05) and positive correlation (R=0.989) between ages measured by BPD and fetuses age measured by FL, this agreed with other studies one by Moawia et al. and Shalev et al, stated that as the gestational age rises; so FL and BPD will rise accordingly. There was strong positive correlation between BPD and FL (r=0.981), also there was strong and positive correlation between FL and GA (0.966). In the same time, the correlation between BPD and GA was strong and positive (0.970) which is a strong and higher than that of FL(r=0.966), but the difference is not significant.

In current study there was significant positive correlation between height to width 2-dimension thalamic size and fetuses ages (R= 0.99), this agreed with other studies that stated there was positive strong correlation between 2 dimension of thalamus and fetuses ages[25-28].

From our study and above realities we found that there was no difference (>0.05) and significant positive correlation (R=0.955) between ages that measured by LMP and ages of fetuses that measured by 2 dimension thalamic size, and no difference (>0.05) and significant positive correlation (R=0.947) between ages that measured by BPD and ages of fetuses that measured by 2 dimension thalamic size, and no difference (>0.05) and significant positive correlation (R=0.953) between ages that measured by FL and ages of fetuses that measured by 2 dimension thalamic size. No study done support this results so must done further study about this.

Conclusions

Although there was no solid mathematical back ground formula for estimation of GA using 2 D thalamic measuring, but according to our research result we conclude that using summation of 2-dimension fetal thalamus to detect the fetal age as a growth parameter is reliable as BPD &FL.

References

1. Deter RL, Harrist RB. Assessment of normal fetal growth. In: Chervena FA, Isaacson GC, Campbell S, Editors. Ultrasound in Obstetrics and Gynecology.1993; 85 :361.

2. Deter RL. Evaluation of quantitative obstetrical ultrasound studies. In: Deter RL, Harrist RB, Birnholz JC, Haldlock FP, Churchill Living Stone 1986; 15-30.

3. Egley CC, Seeds JW, Cefalo RC. Femue length versus biparietal diameter for estimating gestational age in the third trimester. AMJ perinatol. 1986:3(2);77-9

4. Haldlock FP, Deter RL, Harrist RB, Park SK. Estimating Fetal age: Computer assisted- analysis of multiple fetal growth parameters. Radiology 1984; 152(2):497-501.

5. Wu M, Shao G, Zhang F, Ruan Z, Xu P, Ding H. Estimation of fetal weight by ultrasonic examination. Int J Clin Exp Med. 2015;8(1):540–545.

6. Falatah HA, Awad IA, Abbas HY, Khafaji MA, Alsafi KG and Jastaniah, S. (2014) Accuracy of Ultrasound to Determine Gestational Age in Third Trimester. Open Journal of Medical Imaging, 4, 126-132.

7. MacGregor SN, Sabbagha RE. Assessment of Gestational Age by Ultrasound. In: Global Library of Women's Medicine. 2008.

8. Haldlock FP, Deter RL, and Harrist RB. Fetal Biparietal diameter; A critical re-evaluation of the relation to menstrual age by means of real ultrasound: J. ultrasound Med. 1998; 1:97.

9. Snijders, R. J. M. & Nicolaides, K. H. Fetal biometry at 14–40 weeks' gestation. Ultrasound in Obstetrics and Gynecology 4, 34–48(1994).

10. Sotiriadis A, Dimitrakopoulos I, Eleftheriades M, Agorastos T, Makrydimas G. Thalamic volume measurement in normal fetuses using three-dimensional sonography. J Clin Ultrasound. 2012;40[4]:207-13.

11. Xie Y, Chen YA, De Bellis MD. The relationship of age, gender, and IQ with the brainstem and thalamus in healthy children and adolescents: a magnetic resonance imaging volumetric study. J Child Neurol. 2012;27[3]:325-31.

12. Dafna S, C. LR, Mallar CM, P. LJ, J. TM. The developing human brain: age-related changes in cortical, subcortical, and cerebellar anatomy. Brain and Behavior. 2016;6[4]:e00457.

13. Schmahmann JD. Vascular syndromes of the thalamus. Stroke 2003;34:2264.

14. De Salles AA, Bittar GT Jr. Thalamic pain syndrome: anatomic and metabolic correlation. Surg Neurol 1994;41:147.

15. Tamura R, Kitamura H, Endo T, et al. Reduced thalamic volume observed across different subgroups of autism spectrum disorders. Psychiatry Res 2010;184:186.

16. Sadler TW. Central nervous system. In: Sadler TW, ed. Langman's Medical Embryology. Baltimore: Williams & Wilkins, 1985: 334–69 7.

17. Larsen WJ. Development of the brain and cranial nerve. In: Larsen WJ, ed. Human Embryology. New York: Churchill Livingstone, 1993: 375–418.

18. Pansky P. The diencephalon. In: Pansky P, ed. Review of Medical Embryology. New York: Macmillan Publishing, 1982: 406–7.

19. Yang, R., Wang, F., Zhang, J., Zhu, C. & Fan, L. Ultrasonic measurements of fetal thalamus, caudate nucleus and lenticular nucleus in prenatal diagnosis. National Medical Journal of China 95, 1537–1539 (2015).

20. Moawia Gameraddin, Baderldin Alhaj, Mead Zain Alabdeen. The Reliability of Biparietal Diameter and Femoral Length in Estimation the Gestational Age Using Ultrasonography. The Internet Journal of Gynecology and Obstetrics 2, 112 (2014).

21. Shalev E., E. Feldman, E. Weiner, and H. Zuckerman. Assessment of gestational age by ultrasonic measurement of femur length. Acta Obstetrica and Gynecologica et. Scandinavica 1985; 64(1):71.

22. Dr. M.V. Muralidhar, Dr. V. Ramasree, Dr. M.D. Nazia Farha, Dr. Ch. Srinivasarao. Comparative Study of Gestational Age by L.M.P and Foetal Parameters Using Ultrasound. Journal of Dental and Medical Science. Volume 17, Issue 5 Ver. 8 (May. 2018), PP 45-49.

23. Kovac CM, Brown JA, Apodaca CC, Napolitano PG, Pierce B, Patience T, et al. Maternal ethnicity and variation of fetal femur length calculations when screening for Down syndrome. J Ultrasound Med 2002;21(7):719-22; quiz 724-5.7.

24. m Karthikeyan, T., Subramaniam, R. K., Johnson, W. M. S. & Prabhu, K. Placental thickness & its correlation to gestational age & foetal growth parameters- a cross sectional ultrasonographic study. Journal of Clinical and Diagnostic Research 6, 1732–1735 (2012).

25. The relationship of age, gender, and IQ with the brainstem and thalamus in healthy children and adolescents: a magnetic resonance imaging volumetric study. Xie Y, C11hen YA, De Bellis MD. J Child Neurol. 2012 Mar; 27(3):325-31.

26. Puberty influences medial temporal lobe and cortical gray matter maturation differently in boys than girls matched for sexual maturity. Bramen JE, Hranilovich JA, Dahl RE, Forbes EE, Chen J, Toga AW, Dinov ID, Worthman CM, Sowell ER. Cereb Cortex. 2011 Mar; 21(3):636-46.

27. Damle, N. R. et al. Relationship among interthalamic adhesion size, thalamic anatomy and neuropsychological functions in healthy volunteers. Brain Structure and Function 222, 2183–2192 (2017).

28. Tutunji, R. et al. Thalamic volume and dimensions on MRI in the pediatric population: Normative values and correlations: (A cross sectional study). European Journal of Radiology 109, 27–32 (2018).