ORIGENAL ARTICLE

Role of measurement of Fetal Thigh Circumference by Ultrasound in Estimation of Birth Weight

Abdou Saeed Ait-Allah[1], Mohamed Ali Abdelrahman Anan[2], Diaa Mohamed Dawyee*[2], Nahla Waer Alsayed Shady[2]

[1]Department of Obstetrics and Gynecology, Faculty of Medicine – Sohag University, Egypt.

[2]Department of Obstetrics and Gynecology, Faculty of Medicine – Aswan University, Egypt.

ABSTRACT

Keywords:

Measurement of Fetal Thigh Circumference, Ultrasound, Birth Weight.

***Corresponding Author:**

Diaa Mohamed Dawyee. Mobile: (+20)01014090068, E-Mail: dr.diaa922@gmail.com

Background: Accurate estimation of fetal weight is the corner stone of fetal growth assessment to avoid risk of fetal hypoxia, cesarean section, fetal injury, and maternal complications. **Objective:** Evaluation of the accuracy of predicting birth weight by incorporating fetal thigh circumference in the formula of estimating birth weight using 2D-Ultrasound. **Patient and methods:** This study was a prospective cohort study had been conducted on 228 pregnant women admitted for planned delivery at term (between 37-41 weeks) were subjected to ultrasound examination (fetal anatomy and fetal biometry) at obstetrics and gynecology department Aswan university. Pregnant women were followed up till delivery then mid-thigh circumference measured by tape and newborn babies were weighted in the pediatric department. **Results:** Correlation between Actual Birth Weight and Each of EFW (using Both Formulae) in included women revealed that there was a significant positive correlation between actual birth weight and each of EFW using Hadlock's formula and EFW using Vintzileos' formula., there was more significant positive correlation between actual fetal birth weight and EFW using Vintzileos' formula. **Conclusion:** The fetal thigh circumference measurement adding more accuracy, sensitivity, and specificity in estimation of intra-uterine fetal weight when incorporated with other fetal parameters.

INTRODUCTION

The fetus with growth restriction is at increased risk of hypoxia and perinatal death, on the other hand a macrosomic fetus is associated with an increased risk of cesarean section, fetal injury, and possible maternal complication. In obstetric practice, estimated fetal weight (EFW) is a key tool for identifying and managing both small fetuses (BW ≤ 2500 g) and large fetuses (BW ≥ 4000 g so accurate estimation of fetal weight is considered the corner stone of fetal growth assessment [(1)]. Armed with this information informed decisions about delivery can be taken, thereby minimizing perinatal morbidity and mortality [(2)].

A lot of work had been done to find out accurate methods of estimation of fetal size and weight in utero. They include clinical and ultrasound estimations. Clinical methods include models incorporating height of the uterus and girth of the abdomen which

measured at the level of umbilicus. But the clinical methods were subjected to significant margin of error and were not useful in malpresentations, maternal obesity, multifetal pregnancy, polyhydramnios, and oligohydramnios [3].

Ultrasound methods use many fetal parameters such as BPD, HC, AC, and FL and is better when compared with clinical methods and is more reproducible than clinical one so fetal measurement obtained by perinatal ultrasonography have become an integral part of fetal assessment. They are used for estimating fetal weight and for measuring fetal organs [4].

Most used formulas for estimating fetal weight include measurements of the head circumference, abdominal circumference, and femur length, alone and in combination [5]. The sonographic estimation of gestational age and fetal weight has relied on a series of formulas derived from biometric measurements of the fetus, including the fetal head, abdomen, and femur. These estimates are not highly accurate, with 86.5% of estimates being within 15%of actual birth weight [6].

Estimated fetal weight (EFW) is difficult to be calculated especially when head measurement is hard to obtained, because the fetal head is positioned low in pelvic cavity. A convenient method for estimating fetal body weight without head measurement was thus required. Hence one more parameter, fetal mid-thigh circumference, was added to improve the accuracy of available formulas [7], and the value of fetal thigh circumference measurement in addition to the head, abdominal, and femur length measurements had been investigated [5]. Also, pediatric experience has shown that thigh circumference (TC) is one of the parameters that reflects soft tissue mass [3].

Hoffbauer and co-worker were among the first to include fetal thigh diameter in a weight formula. They draw the conclusion that circumference measurements of fetal thigh could be made in a reliable manner and could be used to detect changes in the soft tissue mass and possibly improve fetal weight estimation [5].

The present study was carried out to evaluate the accuracy and usefulness of predicting birth weight by incorporating fetal thigh circumference in the formula of estimating birth weight using 2D-Ultrasound

.

PATIENTS AND METHODS

This was a prospective cohort study conducted at Aswan university hospital from January 2019 to November 2019, included 228 singleton pregnant women admitted for planned delivery at term (between 37-42 weeks) either by elective cesarean section with different obstetric indications or by vaginal delivery. This study included singleton intrauterine term pregnancy (gestational age from 37-41 weeks), cephalic presentation. Pregnancy duration confirmed by: (A) Reliable dates. (B) or by early ultrasound scan performed during 1st trimester of conception (measuring crown - rump length (CRL) before 12th week of gestation or below 84 mm). Also, Delivery within a week after sonographic weight estimation. The study Excluded cases if there were presence of congenital anomalies , hydrops or intrauterine fetal death (IUFD).

Sample size Estimation:

Sample size was calculated to include 228 singleton term pregnancies. sample size calculation program based on a regression equation mentioned in a study carried out by **Kalantari et al.** [8], the number of independent variables controlled is 3, R2 (C) when controlling independent variables are included in the regression model = 0.69, the number of variables tested is 1, R2 (T/C) is the amount that is added to R2 by those independent variable that are to be tested after fitting those that is controlled for = 0.03.

Out of 438 participating women, 228 women matched the study inclusion criteria and consented to participate in this study.

Ethical consent:

An approval of the study was obtained from Aswan University academic and ethical committee. Every patient signed an informed written consent for acceptance of the operation.

All women were submitted to: History taking with emphasis on maternal age,

parity, gestational age, obstetric, menstrual, and past histories, and verbal consents were obtained before inclusion in the study.

Sonographic examinations: All ultrasound examinations were performed by Philips HD5 Ultrasound at labor ward at Aswan University Hospital.

Ultrasound assessment of fetal anatomy and fetal biometry including the standard fetal biometric measurements

a) Bi-Parietal diameter (BPD): It was measured by the standard method.

b) Head Circumference (HC): HC was calculated by the ellipse method as the standard method.

c) Femur Length (FL): The femur length was measured as the standard method also.

d) Abdominal Circumference (AC): It was measured by the ellipse method as the standard method.

e) Thigh Circumference (TC)

The thigh circumference was measured according to the technique of **Vintzileos et al.** [9]**,** the longitudinal axis of femur was first imaged, the transducer was then rotated 90 degrees to obtain a cross sectional profile of the middle of the thigh at a position that the bone profile was as round as possible, and the boundary of thigh profile must be well defined.

- Fetal weight was estimated within a week of delivery.
- The estimated fetal weight (EFW) was calculated by the formula of **Hadlock et al.** [10] based on BPD, HC, FL, and AC.

Log10 Weight = 1.3596 - 00.00386 AC x FL+ 0.0064 HC + 0.00061 BPD x AC + 0.0424 AC + 0.174 FL)

And the formula based on BPD, AC, FL, and TC [9].

Log10 (Birth Weight) = 1.897 + 0.015 * AC + 0.057 * BPD + 0.054 *FL +0.011*TC.

Pregnant women followed up till delivery and mode of delivery documented in data collection sheet then mid-thigh circumference measured by tape and newborn babies were weighted in the pediatric department.

Fetal weights were classified into 3 categories: Low: less than 2500gm, Average: between 2500-4000gm *and* Larger than average (macrosomia): more than 4000gm.

Statistical analysis:

Data were statistically described in terms of mean ± standard deviation (± SD), median and interquartile range (IQR) (for numeric variable) or number and percentages (for categorical variable). Accuracy was tested by correlating raw values of fetal weight by ultrasound (equations) with that of gold standard (postnatal weight). Difference between actual birth weight (on one side) and EFW using either formula (on the other side) and between EFW using either formula was assessed using paired student's t-test and linear correlation coefficient Test. The paired difference was presented as mean difference ± standard deviation, and the corresponding 95% confidence interval. Association between two metric variables was estimated using Pearson's correlation coefficient. P value, error value was always set at 0.05, P values less than 0.05 was considered statistically significant. All statistical analysis were performed using SPSS 25 program.

RESULTS

The study included 228 singleton pregnant women, the age most of them in the age group from 21-30 years . about 66% of them were multigravida. The mean body mass index about 27.8±3.9 (Table 1).

As regards to the fetal sonographic data, the mean of Biparietal diameter was 9.2cm ± 0.31SD, the mean of Head circumference was 32.07 cm ±1.07 SD, the mean of Abdominal circumference was 33.14 cm ±2.08 SD, the mean of Femur length was 7.22 cm + 0.39SD and the mean of Mid-thigh soft tissue circumference was 16.15 cm±1.20 SD. Male fetuses were 104 fetus, but females were 124. Gestational age mean was 38.1± 1.1 ranging from 37 week to 41 weeks (Table 1).

Table 1: demographic data of the participating women and fetal sonographic data.

Variable		No of cases (%)	Mean± SD	Range
Maternal age (y)	≤ 20	33 (14.4)		
	21 / 30	138 (60.6)		
	30 / 35	48 (21.2)		
	≥ 35	9 (3.8)		
Parity	Primigravida.	76 (33.3)		
	Multi gravida	152 (66.7)		
Fetal sex	Male female	104 (45.5) 124 (54.5)		
Maternal body mass index (kg/m^2)			27.8±3.9	20.7 – 34.7
Gestational age			38.1±1.1	37-41
Sonographic variable				
Biparietal diameter (cm)			9.20±0.31	8.5-9.8
Head circumference (cm)			32.07±1.07	30.4-36.2
Abdominal circumference (cm)			33.14±2.08	29.5-40.76
Femur length (cm)			7.22±0.39	6.2-8
Mid-thigh soft tissue circumference (CM)			16.15±1.20	13-20.6

Sonographic variables were obtained by ultrasound in centimeter unit (n=228)

As regards to diagnostic accuracy of fetal weight in low-birth-weight fetuses by US using Hadlock's Formula (g), The results found that, the sensitivity of test was 80.7%, the specificity was 86.5%, the positive predictive value was 66% and the negative predictive value was 96% with diagnostic accuracy 76.3%. However, when using Vintzileos's Formula (g) to predict the fetal weight we found that, the sensitivity of the test was 90.0%, the specificity of 89%, the positive predictive value of 65% and negative predictive value of 98% with diagnostic accuracy 81.5%. From the above data, Results can show that the Vintzileos's Formula was more sensitive and had good negative prediction value as a diagnostic test to estimate low birth fetal weight (Table 2).

Table 2: Diagnostic accuracy of US using Hadlock's Formula (g) and Vintzileos's Formula (g)

	Sens.	Spec.	PPV	NPV	Accuracy
for low birth weight.					
WT by US Hadlock's Formula (g)	80.7%	86.5%	66%	96%	76.3%
WT by Vintzileos's Formula (g)	90%	89%	65%	98%	81.5%
for high birth weight.					
WT by US Hadlock's Formula (g)	72.6%	95.7%	65.4%	96.6%	72.2%
WT by Vintzileos's Formula (g)	94.2%	98.0%	78.0%	97.4%	89.6%

Sens= Sensitivity, Spec= Specificity, PPV= Positive predictive value, NPV= Negative predictive value

As regards to diagnostic accuracy of fetal weight in high birth weight fetuses by US using Hadlock's Formula (g), we found that, the sensitivity of test was 72.6%, the specificity was 95.7%, the positive predictive value was 65.4% and the negative predictive value was 96.6% with diagnostic accuracy 72.2%. However, when we use Vintzileos's Formula (g) to predict the fetal weight reults found that, the sensitivity of the test was 94.2%, the specificity of 98.0%, the positive predictive value of 78.0% and negative predictive value of 97.4% with diagnostic accuracy 89.6%. From the above data, This study can show that the Vintzileos's Formula was highly sensitive compared with Hadlock's Formula, had good positive prediction value and with high accuracy as a

diagnostic test to estimate high birth fetal weight (Table 2).

In comparison between the results of estimated fetal weight using US in the two equations and the actual weight after delivery of the baby the study found that, the Vintzileos's formula has good estimation to the fetal weight in different body weight groups but the Hadlock's formula overestimating the high birth weight groups and under estimate the normal birth weight groups (Table 3).

Table 3: Comparative analysis between the actual & estimated fetal weight in different weight groups.

Methods	Weight (gm)	No. (%)	Mean± SD (Range)
Actual birth weight	Low birth weight <2500	32 (14.2%)	2318.18±40.45(2002-2400)
	Normal birth weight ≥2500-<4000	160 (67.9%)	3092.27±350.33(2520-4000)
	High birth weight ≥4000	36 (15.9%)	4202.00±96.61 (4105-4400)
Weight by US using Hadlock's formula (BPD, AC and FL)	Low birth weight <2500	28 (12.3%)	
	Normal birth weight ≥2500-<4000	148 (64.7%)	
	High birth weight ≥4000	52 (23.0%)	Actual Fetal Weight (g)
Weight by US using Vintzileos's formula (BP, AC, FL &TC)	Low birth weight <2500	33 (14.4%)	
	Normal birth weight ≥2500-<4000	156 (68.7%)	
	High birth weight ≥4000	39 (16.9%)	

As regard of thigh circumference by US and actual circumference there is no statistically significant difference between mid-thigh circumference by ultrasound and actual thigh circumference of the studied sample, P value >0.05 ().

Table 4: Comparison between mid-thigh circumference by US and actual thigh circumference sample by cm.

Variable	Range	Mean± SD	t-test	P value
Mid-thigh circumference measured by ultrasound	13-20.3cm	16.15±1.20cm	1.142	0.991
Actual postnatal measurement thigh circumference	12.5-19.9cm	16.20±1.22cm		

* Paired sample t-test

The demonstrated significant positive correlation between actual fetal weight (g) with estimated fetal weight by ultrasound using Hadlock's Formula (g) and weight by Vintzileos's Formula (g) was more in Vintzileos's Formula which give more accurate results (Table 5).

Table 5: Correlation of estimated fetal weight by different Formula with actual birth weight.

	Actual fetal birth weight (g)	
	r	**P**
Hadlock Formula	0.88	< 0.001
Vintzileos's Formula	0.93	< 0.001

r Pearson correlation coefficient

DISCUSSION

Accurate estimation of fetal weight is the corner stone of fetal growth assessment to avoid risk of fetal hypoxia, cesarean section, fetal injury, and maternal complications. Antenatal care in regular visits to give the patients psychological support was done. Correlation between actual fetal birth weight and the estimated weight by Vintzileos's formula and by using Hadlock's formula in included women revealed that there was significant positive correlation between actual birth weight and each of EFW using both formulae in the low, average and macrosomia groups. The higher correlation was with EFW using Vintzileos's' formula with {p<0.001} in low-birth-weight group,

{p<0.003} in average birth weight group, and in macrosomia birth weight group was {p<0.06}

So, measurements of thigh circumference provide a potentially straight forward method for assessing the deposition of muscle and fat in the growing fetus. This parameter is preferred over diameter measurements as it is less sensitive to changes in shape.

This results were matched with **Vintzileos et al.** [9] who incorporated thigh circumference measurement in addition to the head, abdominal, and femur length measurements in their formula to predict birth weight by ultrasound. The mean error of this formula was 6% and the mean deviation 0.3%. Their data suggested the addition of thigh circumference to measurements of the head, abdomen and femur length improves the accuracy of fetal weight estimates.

In agreement with this study study**, Faver et al.** [11] conducted a prospective study on fetal weight estimation using TC as one of the parameters. They confirmed that, the use of thigh circumference not only enhanced the detection of small for dates fetuses, but also macrosomic fetuses.

In agreement with this study, **Shripad and Varalaxmi** [3] stated that fetal thigh circumference measurements scan add further to the accuracy of birth weight estimation in obstetric practice especially in babies of <2.5 kg with 95% predictability. They found that, measurements of TC provide a potentially straight forward method for assessing the deposition of muscle and fat in the growing fetus. This parameter is preferred over other fetal diameters measurements as it is less sensitive to change in shape.

The result of this study is also supported by **Kanakaraj et al.** [12] in which, they compared the birth weight by different formulas. In all the weight groups estimated fetal weight by Vintzileos formula is close to the actual weight. Percentile values for absolute error are least with Vintzileos formula and highest with Johnson's formula (out of scope of our study) as 89.1% of predictors were within 10% of error with Vintzileos's formula as compared with 65.5, 32.7, 26.4 by Hadlock, SFH x GA, Johnson's formula respectively.

Vintzileos formula which included BPD, AC, FL, and thigh circumference is more accurate than Hadlock's formula which included only BPD, AC and FL. Thigh circumference inclusion in routine ultrasound is strongly recommended to improve the birth weight estimates.

The results of the current study are the same road of **Simpson et al.** [13] who concluded that the fetal thigh circumference, if incorporated with other standard biometric parameters in estimating fetal weight by ultrasound, improves the predictability of birth weight estimation, and can predict intrauterine growth restriction.

In addition, they found that, most of the study population, the mean fetal weight estimated by Vintzileos' formula was nearer to the mean actual birth weight compared to the Hadlock's formula.

Also, in accordance with our study, **Rizwan et al.** [14] study in which, he used the Isobe's formula depending on the thigh measurements was used without the need for head circumference and he found that, it would be useful in daily clinical practice for estimation of fetal weight, especially in cases in which head measurements are impossible. It would be convenient among all the formulas involving only two thigh parameters while using conventional, two-dimensional ultrasound examination for fetal weight estimation without the need for head measurement near term.

Song et al. [15] **and Lee et al.** [16] proved that, imaging fetal limb volume by 3D ultrasound using fetal thigh measurements facilitate accurate prediction of birth weight which used as a model to predict fetal weight by using a combination of the abdominal circumference and the fractional thigh volume and showed that, estimations of fetal weight had a 0.5 systematic error and a 7% random error and their model was superior to the widely used models based on conventional ultrasound formulae (9 percent systematic error and 9 percent random error),

However not all centres are equipped with 3D ultrasound machines and there are some limitations associated with 3D imaging

techniques in optimal visualization of the surface anatomical structures, especially in cases of fetal malpresentations and mal positions [17].

Moreover, not many ultra-sonographers and doctors are currently well trained in 3 D ultrasound. Until these problems are solved, it can be inferred that the thigh circumference measurements using 2D ultrasound add to obstetrician's ability to predict intrauterine growth abnormalities.

In agreement with this study, the sensitivity, specificity, accuracy, positive predictive value, and negative predictive value all in the same road of the results of 3D results of **Song et al. [15] and Lee et al. [16]** so we can depend on the 2D ultrasound results especially when the machine and well-trained sonographer not found.

Conclusion

This study can conclude that, the fetal thigh circumference measurement adding more accuracy, sensitivity, & specificity in estimation of intra-uterine fetal weight when incorporated with other parameters. Using of Vintzileos' formula would be useful in daily clinical practice for fetal weight estimation of.

RECOMMENDATIONS

At the end of this study, the study recommend using Vintzileos' formula as a parameter to calculate expected fetal weight by ultrasound in obstetric practice.

REFERENCES

1. **Heiskanen N, Raatkainen K, Heinonen S. (2006):** Fetal macrosomia – a continuing obstetric challenge. Biol Neonate, 90:98 -103.
2. **Ikubor JE. (2011)**: Correlation of sonographically estimated birth weight and actual birth weight among pregnant women at the University of Benin Teaching Hospital. National Postgraduate Medical Collage of Nigeria (FMCR), 23:1449–52.
3. **Shripad H, Varalakshmi N. (2007):** Comparison of three ultrasound ratios in term low birth weight babies - is there a role for thigh circumference? Calicut Medical Journal, 5(3): 69-78.
4. **Ergaz U, Goldstein I, Weiner Z. (2015)**: A Preliminary Study of Three-dimensional Sonographic Measurements of the Fetus. Rambam Maimonides Medical Journal, 6: 19-24.
5. **Papageorghiou A, Sarris I, Ioannou C, Todros T, Carvalho M, Pilu G, Salomon L. (2013):** The International Fetal and Newborn Growth Consortium for the 21st Century (Intergrowth-21st): Ultrasound methodology used to construct the fetal growth standards in the INTERGROWTH-21st Project. BJOG, 120(2): 27–32.
6. **Scioscia M, Vimercati A, Ceci O, Vicino M, Selvaggi LE. (2008):** Estimation of birth weight by two-dimensional ultrasonography acritical appraisal of its accuracy. Obstet Gynecol., 57:111-116.
7. **Kalpana M, Kavita S. (2017):** Role of fetal thigh circumference in prediction of fetal weight and comparing it with other clinical and ultrasound methods. Indian Journal of Research, 6(1):85-87.
8. **Kalantari Z, Ferreira CSS, Walsh RP, Ferreira AJ, Destouni G. (2013):** Urbanization Development under Climate Change: Hydrological Responses in a Peri-Urban Mediterranean Catchment. International Journal of Industrial Engineering Computations, 28(7): 2207 – 2221.
9. **Vintzileos AM, Campbell WA, Rodis JF, Bors-Koefoed R, Nochimson DJ. (1987):** Fetal weight estimation formulas with head, abdominal, femur, and thigh circumference measurements. Am J Obstet Gynecol., 157: 410-414.
10. **Hadlock FP, Harrist RB, Sharman RS. (1985):** Estimation of fetal weights with the use of head, body, and femur measurements a prospective study. Am J Obstet Gynecol., 15: 13-33.
11. **Faver R, Bader AM, Nisand G. (1995):** Prospective study on fetal weight estimation using limb circumferences obtained by three-dimensional ultrasound. Ultrasound Obstet Gynecol., 6(2): 140-4.
12. **Kanakaraj K, Mariappan K, Farid S. (2017):** Estimation of Foetal Weight

at Term Pregnancy by Clinical and Ultrasonographic Methods. Sch Acad J Biosci., 5(1):72-77.

13. **Simpson JW, Lawless RW, Mitchell AC. (2012):** Influence of pre pregnancy weight gain on birth weight. Obstet Gynecol., 45: 481-85.
14. **Rizwan S, Tariq S, Tahir S, Sughra F. (2008):** Estimation of fetal weight in third trimester using thigh measurements. J Ayub Med Coll Abbottabad., 20 (3): 92-106.
15. **Song TB, Moore TR, Lee JI, Kim YH, Kim EK. (2000):** Fetal weight prediction by thigh volume measurement with three-dimensional ultrasonography. Obstet Gynecol., 96(2): 157-61.
16. **Lee W, Deter RL, Ebersole JD, Huang R, Blanchaert K, Romero R. (2001):** Birth weight prediction by three-dimensional ultrasonography: fractional limb volume. J Ultrasound Med., 20(12): 1283-92.
17. **Matsumoto M, Yanagihara T, Hata T. (2000):** Three-dimensional qualitative sonographic evaluation of fetal soft tissue. Human Reproduction, 15: 2438-2442.