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Research Article

Assessment of the Accuracy of Incorporation of Fetal Thigh Circumference in the Formula of Estimating Birth weight Using Two-Dimensional Ultrasound

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Abstract

Background: The ultrasound estimation of fetal weight through Bi Parietal Diameter, Abdominal Circumference, Head Circumference and Femur Length is an important component in obstetrics since it is directly related to gestational age, which assists in the planning of the mode of delivery and labour management. It offers information on IUGR (intrauterine growth restriction) and is useful in preventing preterm delivery. It also helps to reduce prenatal morbidity and mortality**.** Aim and objectives: To assess The Accuracy of Incorporation of Fetal Thigh Circumference in The Formula of Estimating Birth weight. **Methods:** This cross-sectional study was performed at Minia University, Maternity and Children Hospital from January 2021 to December 2022. The study included 1000 singleton pregnant women admitted for planned delivery at term (between 36-40 weeks) either by elective cesarean section with different obstetric indications or by induction of labour and vaginal delivery. **Results:** The maternal ages ranged from 24 to 40, with a mean of 31.95 ± 3.08 years. The value of mid-thigh circumference (measured in centimeters) varied from 3.6 to 29.9, with an average of 12.96 ± 6.86. The estimated birth weight (BW) and actual BW were determined by Hadlock and Vintzileos. The mean actual BW in was 3.1 ± 0.59. The estimated BW according to Hadlock's method varied from 2.03 to 4.08, with a mean value of 3.05 ± 0.62. While, Vintzileos' estimated birth weight ranged from 2.29 to 4.66, with a mean of 3.16± 0.64. **Conclusion**: The measurement of fetal thigh circumference with other parameters enhances the accuracy, sensitivity, and specificity in estimating intra-uterine fetal weight. The application of Vintzileos' formula might be beneficial in routine clinical practice for estimating fetal weight.

Keywords: Fetal Weight, Vintzileos, Hadlock, Fetal Thigh Circumference

Introduction

The application of ultrasound technology for the estimation of fetal weight, utilizing biometric parameters such as bi parietal diameter (BPD), abdominal circumference (AC), head circumference (HC), and femur length (FL), carries substantial importance within the realm of obstetrics. The estimation mentioned is strongly linked to gestational age, hence assisting in the identification of suitable delivery techniques and the efficient administration of labor. This resource offers significant insights on intrauterine growth restriction (IUGR) and its possible impact on the prevention of preterm delivery. Furthermore, previous research has demonstrated that it exerts a beneficial influence on reducing rates of neonatal morbidity and mortality [(1)].

There are two primary techniques commonly utilized for assessing birth weight: sonographic or ultrasound examinations and clinical procedures. The measurement of uterine height

and girth at the umbilicus is frequently utilized in therapeutic settings. Nevertheless, it is crucial to acknowledge that this particular approach is linked to a substantial margin of error and is not suitable for instances involving polyhydramnios, oligohydramnios, maternal obesity, malpresentation, and multifetal pregnancy[(2)].

The prevailing method employed to determine the weight of a fetus in present-day medical practice entails the application of an equation that incorporates multiple measurements, including head circumference (HC), abdominal circumference (AC), femur length (FL), and bi-parietal diameter (BPD), as variables [(3).]
Moreover, proposed the inclusion of a new criterion called fetal thigh circumference (TC) alongside the currently utilized sonographic biometric indicators. The application of thigh circumference as a means of assessing newborn birth weight is seen as more reliable due to its ability to identify changes in soft tissue masses [(4)].

The inclusion of fetal thigh circumference, in conjunction with other parameters such as bi parietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL), resulted in enhanced accuracy when determining fetal weight. The methodology described above demonstrates an average error rate of 6% and an average divergence of 0.3%. An unborn fetus that is affected by intrauterine growth restriction (IUGR) is at an increased risk of experiencing hypoxia and perinatal death. Likewise, an infant with macrosomia exhibits an elevated likelihood of necessitating a cesarean delivery. Hence, the establishment of a strong association between fetal thigh circumference and birth weight would yield significant benefits in the context of the prenatal period, as it would facilitate timely identification of such growth problems. [(5)].

Moreover, the application of this technique would result in notable benefits in the pre-induction evaluation of pelvic disproportion. With the utilization of this learned knowledge, it becomes feasible to expeditiously determine the appropriate approach for delivery, leading to a decrease in infant morbidity and fatality rates [(6)].

The researchers have arrived at the determination that the incorporation of thigh circumference, in conjunction with other prenatal indications, enhances the accuracy of predicting birth weight. A robust correlation has been shown between prenatal and postnatal assessments of thigh dimensions, with ultrasonography proving to be a reliable method for precisely reconstructing the actual thigh circumference. The study conducted by Shripad H and Varalaxmi N in 2005 examined the use of ultrasonography to establish a relationship between fetal thigh circumference during the gestational period of 36-40 weeks and birth weight. Recent research has indicated that thigh circumference can be utilized as a viable alternative to biparietal diameter for assessing birth weight during or near term, particularly in cases when measuring biparietal diameter is hindered by the fetal head's posture in proximity to the pelvic bone. This phenomenon can be attributed to the heightened correlation observed between thigh circumference and birth weight. [(7)]

Aim of the work

The primary aim of this study is to assess the accuracy of incorporating fetal thigh circumference as a variable in the existing formula utilized for predicting birth weight.

Patients and methods

Study Design:
This is a cross-sectional study.

Study Setting:
This study was performed at Minia University, Maternity and Children Hospital from January 2021 to December 2022. Minia University Maternity Hospital is a tertiary hospital receiving referrals from 9 local regions of around 6 million population numbers.

Study Population:
The participants of the study were pregnant women who were admitted for scheduled delivery at full term (between 36-40 weeks). These women underwent either elective cesarean section for various obstetric reasons or

induction of labor followed by vaginal birth. The scans were performed within 24 hours before the delivery.

Selection of Patient:

Inclusion criteria:

1. Singleton intrauterine term pregnancy of gestational age (36-40 weeks).
2. Pregnancy duration confirmed either by using Nagele's formula or 1st trimester ultrasound scan (sure pregnancy dating)
3. Live born baby.
4. Intact membranes.

Exclusion criteria:

1. Presence of congenital anomalies.
2. Intrauterine fetal death (IUFD).
3. Rupture of membranes.
4. Breech presentation.
5. Diabetes Mellitus.
6. Hypertensive disorders.
7. Oligohydramnios and Polyhydramnios.

Sample size Estimation:

Assuming an error in fetal weight estimation ranging between 7-15%, a sample size of one thousand (1000) cases is enough to detect such rate

x = Z(c/100) ^2 r (100-r)

n = N x/ ((N-1) E2 + x)

E = Sqrt [(N - n) x/n (N-1)]

Where N is the population size, r is the fraction of responses that you are interested in, and Z(c/100) is the critical value for the confidence level c. CI 95%

Method:

All patients were subjected to:

1. Complete history taking:

- Personal history: name, age, parity, residence.
- Maternal age
- Gestational age
- Obstetrical history.
- Menstrual history
- Past medical history: cardiac problems, hypertension, chest diseases, renal diseases, liver diseases, blood diseases or bleeding tendency.

2. Sonographic examinations:

- An expert radiologist conducted all ultrasound tests using a Voluson ultrasound system in the labor ward at Minia University Maternity Hospital.
- The fetal anatomy and size will be evaluated by ultrasound, which includes measuring the typical fetal biometric parameters such as biparietal diameter (BPD), head circumference (HC), femur length (FL), abdominal circumference (AC), and thoracic circumference (TC).
- Fetal weight was assessed either during the initial phase of typical labor or within 24 hours before to a planned cesarean section. The estimated fetal weight (EFW) was determined using the Hadlock et al formula, which takes into account the measurements of BPD, HC, FL, and AC (Hadlock and al, 1985).

(Birth Weight) = 1.3596 - 0.00386 AC x FL+ 0.0064 HC + 0.00061 BPD x AC + 0.0424 AC + 0.174 FL)

And the formula of Vintzileos based on BPD, AC, FL and TC

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

Ethical Consideration

Approvals were obtained from the Ethics Committee of Faculty of Medicine, Minia University. After informing each participant of the study's goal, nature of the study, as well as the risk–benefit assessment and guaranteeing that their data would remain anonymous and not be used for anything but scientific research, the researcher obtained their informed consent.

Results

Table (1) showed Demographic and clinical data among the study participants. Maternal age ranged from 24 to 40 with mean ± SD = 31.95 ± 3.08. About one-third 333 (33.30%) of pregnant women were primigravida. The mean of gestational age was 38.02 ± 0.94. Number of pregnant women who had male fetus was 455 (45.50%).

The bi-parietal diameter (cm) in the study group varied from 2.3 to 15.2; with a mean value of 7.25 ± 3.56 (mean ± standard deviation). The average head circumference was 25.25 ± 12.36. The mean value of abdominal circumference was 26.32 ± 13.58. The range of femur length (cm) in the study population was 1.9 to 12.5, with a mean of 5.75 ± 2.91. The mid-thigh circumference (cm) varied from 3.6 to 29.9, with an average value of 12.96 ± 6.86 (Table 2).

Table (3) displayed the estimated birth weight (BW) and actual BW according to Hadlock and Vintzileos' calculations. The mean actual BW in was 3.1 ± 0.59. The estimated BW according to Hadlock's method varied from 2.03 to 4.08, with a mean value of 3.05 ± 0.62. While, Vintzileos' estimated birth weight ranged from 2.29 to 4.66, with a mean of 3.16± 0.64.

Table (4) showed Categories of Hadlock and Vintzileos' estimated BW and actual BW among the study population. Number of pregnant women with high actual BW was 70 (7%). The number of pregnant women with estimated high birth weight by Hadlock's formula was 58 (5.80%), and by Vintzileos' formula were 148 (14.80%).

Table (5) showed Diagnostic accuracy of US using Hadlock's and Vintzileos's Formulas in predicting high birth weight. Accuracy of Hadlock's Formula for predicting low birth weight was 75.7%. Accuracy of Vintzileos's Formula for predicting low birth weight was 85.4%.

Table (1): Demographic and clinical data among the study population

	Study population (n = 1000)
Maternal age (y)	
Mean ± SD.	31.95 ± 3.08
Range (Min-Max)	16 (24 - 40)
Parity	
Primigravida	333 (33.30%)
Multi gravida	667 (66.70%)
Gestational Age	
Mean ± SD.	38.02 ± 0.94
Range (Min-Max)	4 (36 - 40)
Fetal sex	
Male	455 (45.50%)
Female	545 (54.50%)

Table (2): US parameters among the study population

	Study population (n = 1000)
Biparietal diameter (cm)	
Mean ± SD.	7.25 ± 3.56
Range (Min-Max)	12.9 (2.3 - 15.2)
Head circumference (cm)	
Mean ± SD.	25.25 ± 12.36
Range (Min-Max)	44.4 (8.6 - 53)
Abdominal circumference (cm)	
Mean ± SD.	26.32 ± 13.58
Range (Min-Max)	51.4 (7.9 - 59.3)
Femur length (cm)	
Mean ± SD.	5.75 ± 2.91
Range (Min-Max)	10.6 (1.9 - 12.5)
Mid-thigh circumference (cm)	
Mean ± SD.	12.96 ± 6.86
Range (Min-Max)	26.3 (3.6 - 29.9)

Table (3): Hadlock and Vintzileos' estimated BW and actual BW among the study population

	Study population (n = 1000)
Actual BW	
Mean ± SD.	3.1 ± 0.59
Median (IQR)	2.94 (2.57 - 3.66)
Range (Min-Max)	1.93 (2.25 - 4.18)
Hadlock's estimated BW	
Mean ± SD.	3.05 ± 0.62
Median (IQR)	2.92 (2.51 - 3.64)
Range (Min-Max)	2.05 (2.03 - 4.08)
Vintzileos' estimated BW	
Mean ± SD.	3.16 ± 0.64
Median (IQR)	2.94 (2.62 - 3.67)
Range (Min-Max)	2.37 (2.29 - 4.66)

Table (4): Categories of Hadlock and Vintzileos' estimated BW and actual BW among the study population

	Study population (n = 1000)
Actual BW categories	
- High birth weight	70 (7%)
- Normal birth weight	763 (76.30%)
- Low birth weight	167 (16.70%)
Hadlock's estimated BW categories	
- High birth weight	58 (5.80%)
- Normal birth weight	696 (69.60%)
- Low birth weight	246 (24.60%)
Vintzileos' estimated BW categories	
- High birth weight	148 (14.80%)
- Normal birth weight	703 (70.30%)
- Low birth weight	149 (14.90%)

Table (5): Diagnostic accuracy of US using Hadlock's and Vintzileos's Formulas for predicting low birth weight

	Diagnostic parameters				
	Sensitivity	**Specificity**	**PPV**	**NPV**	**Accuracy**
Hadlock's Formula	50.90%	80.67%	34.55%	89.12%	75.70%
Vintzileos's Formula	50.90%	92.32%	57.05%	90.36%	85.40%

Discussion

The accurate measurement of fetal weight is widely recognized as a crucial element in evaluating fetal growth. By employing this information, individuals are able to make informed decisions regarding the mode of delivery, hence decreasing the incidence of perinatal illness and mortality [(10)].

Considerable endeavors have been made to determine accurate methodologies for assessing fetal dimensions and mass during the course of prenatal growth. The techniques utilized comprise both clinical assessments and ultrasonography estimations. Various clinical procedures involve the utilization of different models that incorporate the assessment of the uterine height and abdominal girth, specifically at the umbilical level. Nevertheless, it is important to acknowledge that the clinical methodologies utilized in this investigation exhibited a significant degree of imprecision and were not deemed efficacious in instances characterized by malpresentations, maternal obesity, multifetal pregnancy, polyhydramnios, and oligohydramnios [(11)].

Ultrasound techniques are utilized to measure many fetal metrics, such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). These methods demonstrate enhanced performance when compared to clinical treatments and offer greater reproducibility than the latter. As a result, the acquisition of fetal measures using perinatal ultrasonography has emerged as a crucial element in the evaluation of the fetus. The utilization of ultrasound technology is employed for the purpose of estimating the weight of the fetus and measuring the measurements of fetal organs. The assessment of fetal weight is a frequently employed practice in which many formulas are utilized, incorporating measurements of the head circumference, belly circumference, and femur length, either independently or in conjunction [(12)].

The estimation of gestational age and fetal weight by sonographic methods has historically relied on a collection of formulas derived from biometric measurements of different fetal characteristics, including head circumference, belly circumference, and femur length. The precision of these calculations is quite limited, as merely 86.5% of forecasts align with the actual birth weight within a 15% deviation. The determination of estimated fetal weight (EFW) can pose challenges, especially in situations when getting precise measurements of the fetal head is hindered by its deep location within the pelvic cavity. Hence, a pragmatic methodology was required to assess the fetal weight without dependence on cranial measurements[(13)].

Consequently, to improve the accuracy of current calculations, an extra parameter, specifically the fetal mid-thigh circumference, was included. Additionally, the evaluation of fetal thigh circumference was conducted in combination with measurements of head circumference, abdomen circumference, and femur length. Moreover, previous research in the domain of pediatrics has provided evidence to support the notion that thigh circumference (TC) can serve as a dependable measure for assessing soft tissue mass [(14).]

Hoffbauer et al., were among the early researchers that integrated fetal thigh diameter as a constituent in a weight formula.[(15)] have established that obtaining accurate measurements of fetal thigh circumference is feasible. This measurement has the potential to detect

deviations in soft tissue mass and perhaps improve the precision of estimating fetal weight.

The main results of the study show:
The study sample comprised 333 primigravida pregnant women, constituting 33.30% of the overall population. The results of our study align with the findings of Ait-Allah, who conducted research including a cohort of 228 pregnant women who were not pregnant with multiple fetuses. The majority of female individuals included in this study were found to be between the ages of 21 and 30 years. Around 66% of the people under examination were categorized as multigravida. The mean body mass index (BMI) is estimated to be around 27.8 with a standard deviation of 3.9.Moreover, the study conducted by Ali et al., (2022) utilized a sample comprising of women with a mean age of 26.68 years (standard deviation = 5.24) and an average gestational age of 38.78 weeks (standard deviation = 0.85).

The most prevalent parity category, including 64.2% of instances, was observed to be within the range of 1 to 2. Furthermore, it was observed that a significant proportion of the female participants, specifically 21.1%, were categorized as nulliparous based on the findings of the study .The present investigation provided evidence regarding the fetal data among the selected study population. The study population exhibited a range of gestational ages (GA) from 36 to 40, with a mean value of 38.02 ± 0.94, as indicated by the standard deviation (SD). The study cohort comprised 455 pregnant women, representing 45.50% of the overall sample .The results of our study align with the research conducted [(17)] which demonstrated that the mean gestational age was 39.2 weeks, with a variation spanning from 37 to 41 weeks. Swedan and Emam (2023) conducted a study which revealed that the gestational age varied between 37 and 40 weeks, with a mean of 38.3± 1.1 weeks .The assessment of fetal growth is a crucial component of prenatal healthcare, as it enables the detection of fetuses that may be more susceptible to adverse health outcomes or mortality in the postnatal phase.

The identification and recognition of fetal growth restriction (FGR) and large for gestational age (LGA) fetuses are crucial in order to develop successful strategies and implement appropriate healthcare measures. Fetal growth restriction (FGR) refers to the condition in which fetuses have a birth weight that is below the 10th percentile. This condition is considered the most significant risk factor connected with stillbirth. Based on the research conducted [(18)], it has been observed that fetuses categorized as big for gestational age (LGA), with a birth weight beyond the 90th percentile, exhibit an increased likelihood of encountering shoulder dystocia, resulting in raised rates of emergency caesarean sections . Since the implementation of updated recommendations for managing fetal growth restriction (FGR) to reduce the occurrence of stillbirths, there has been a significant increase in the use of ultrasound examinations to measure fetal growth. An ultrasonic growth scan involves measuring three fetal biometry parameters: head circumference (HC), abdominal circumference (AC), and femur length (FL), in addition to additional examinations. [(19)].

The National Health Service Fetal Anomaly Screening Programme implements certain criteria and reference points for each measurement, with the objective of ensuring accuracy and uniformity while reducing disparities among various operators and within the same operator. According to, the British Medical Ultrasound Society (BMUS) has declared the utilization of the bi parietal diameter (BPD) measurement as an outdated approach for evaluating the fetal head in the United Kingdom. The current study revealed significant findings among the sample group in relation to parameters peculiar to the United States. The study population displayed a range of bi parietal diameter measurements (in centimeters) from 2.3 to 15.2, with a mean value of 7.25 ± 3.56. The study sample displayed a diverse distribution of head circumferences, ranging from 8.6 to 53 centimeters, with a mean value of 25.25 ± 12.36. The study group exhibited a range of abdominal circumference (cm) spanning from 7.9 to 59.3, with a mean value of 26.32 ± 13.58. The sample population displayed a variation in femur lengths (measured in centimeters) ranging from 1.9 to 12.5, with an average value of 5.75 ± 2.91. The study cohort displayed a

diverse range of mid-thigh circumference measurements, ranging from 3.6 to 29.9 centimeters [20].

This study has shown that the estimation of intra-uterine fetal weight can be more precise, sensitive, and specific when the assessment of fetal thigh circumference is combined with other measures. For the aim of calculating fetal weight in a routine clinical context, Vintzileos' formula may be useful.

Recommendations

- Additional research is required to validate our core findings and ascertain the risk variables associated with unfavorable outcomes. This necessitates conducting studies with a bigger sample size and a longer duration of follow-up.
- It is recommended that efforts be made to enhance the quality of healthcare delivered to patients, alongside the implementation of regular and ongoing monitoring of patient data.

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