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Three-versus Two-Dimensional Sonographic Biometry for Predicting Birth Weight at Term

S.M.A .Metwally, M.F.Alsherbiny, M.A.Elsayed and S.N.Abuelezz
Obstetrics & Gynecology,Dept.,Faculty of Medicine, Benha Univ., Benha, Egypt
Email: samahmetwally588@gmail.com

Abstract

Because aberrant intrauterine growth is related with increased newborn morbidity and death, an accurate estimate of foetal weight is a crucial issue in perinatal treatment. Fetal biometric measures were taken using a 2D ultrasound to determine the birth weight of the baby. The purpose of this study is to compare the reliability of the traditional two-dimensional Hadlock formula for predicting foetal weight to that of three-dimensional ultrasound measurements of foetal thigh volume. Methods: One hundred pregnant women who presented to the Obstetrics and Gynecology department at Benha University Hospital with a singleton live pregnancy between weeks 37 and 40 and no foetal abnormality were included in the research. Patients carrying more than one child, who were in active labour, or who were pregnant with a medical condition were not included in the research. Before anybody took part in the research, they signed informed consent forms. The ranges for anticipated weight using 2D and 3D sonography are (2540–4010) and (2670–3810), respectively. Variations in 3D sonographic thigh volume were seen between (59.62 to 92.52). Comparing the weight predicted by 2D sonography and 3D sonography yielded similar results (P=0.883). Two-dimensional sonography could not accurately predict birth weight (P = 0.582). The discrepancy between the 3D sonographer's estimate and the actual birth weight was not statistically significant (P = 0.403). Actual birth weight was positively correlated with 2D sonography prediction (P 0.001). The actual birth weight was also positively correlated with the anticipated birth weight using 3D sonography (P 0.001). Predicting an expected birth weight for a foetus is aided by measuring the fractional TVol, the authors conclude. Measurements of fractional limb volume may be used to assess foetal size and growth at various stages of pregnancy, and future quantitative investigations should provide light on this topic. Exploring the best birth weight algorithm that adds TVol into conventional birth weight formulas requires large prospective research. Before this indicator may be used in clinical practise, further prospective studies are needed to determine whether or not soft tissue alterations, as measured by TVol, are associated with foetal growth limitation or macrosomia.

Key words: Three Dimensional Sonographic Biometry, Two Dimensional Sonographic Biometry, Predicting, Birth Weight.

1. Introduction

As aberrant intrauterine growth is linked to increased newborn morbidity and death, an accurate estimate of foetal weight is a crucial issue in perinatal treatment. Fetal biometry measures were taken using a 2D ultrasound to determine the birth weight [1].

The biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length are some of the prenatal biometry used in the traditional 2D equations for foetal weight prediction [2].

As the due date approaches, it becomes more difficult to estimate the foetal weight because the amniotic fluid volume decreases and the baby's head sinks into the pelvis. Here, non-traditional metrics, such as 3D ultrasonographic biometry, may supplement the predictive power of more standard ones, such clinical estimate and 2D biometry [3].

It is widely established that the foetal thigh volume (ThV) is connected to foetal development and nutritional condition, leading many researchers to suggest assessing foetal size using soft tissue examination of the foetal thigh thickness or circumference [4].

Because the measurement is taken in a cross section in a single plane, it is challenging to get an accurate volume for the foetal thigh. Now that three-dimensional (3D) ultrasound imaging is widely accessible, the measurement of fractional thigh volume may help clinicians get around some of the technical hurdles associated with foetal weight estimates [5].

Some researchers have shown that prenatal limb volumetry may provide more accurate estimates of birth weight than can the more commonplace 2D ultrasound parameters. It has been shown that BW can be predicted using formulae derived from such volume data with absolute percentage errors lower than 6%. [6].

The purpose of this study is to compare the reliability of the traditional two-dimensional Hadlock formula for predicting foetal weight to that of three-dimensional ultrasound measurements of foetal thigh volume.

2. Patients and Methods

1.2Study design

A prospective observational study.

2.2Study settings

This study was carried out at Obstetrics & Gynecology department, Benha university hospitals.

3.2Study population

One hundred pregnant women between 37 and 40 weeks of gestation who were admitted for termination of pregnancy were enrolled in the study. The study was explained and an informed written consent was obtained from all participants.

4.2Demographic characteristics:

No limitations regarding age, parity, body mass index or race.

5.2Patients' selection

Inclusion criteria:

- Pregnant women at 37 to 40 weeks of gestation who were admitted for termination of pregnancy either by induction of labor or elective caesarean section gestation age was calculated from the first day of the last normal menstrual period (LMP) provided its sure and reliable (regular cycles for the preceding three months and no hormonal contraception, no pregnancy neither lactation). Otherwise gestation age was calculated from early first -trimester ultrasound.
- Women with singleton pregnancy.
- Normal fetal anatomy during obstetric scans.
- Delivery was within 7 days from ultrasound scan.

Exclusion criteria:

- Abnormal amount of liquor.
- Uterine or ovarian swellings.
- Any factor interfering with establishing the needed measurements.
- Congenitally malformed fetuses.
- Multiple pregnancies.
- Patients in active labour and pregnancy with comorbidities.

Methodology

After enrollment all cases were subjected to the following:

- Complete history taking including past, medical, obstetric and gynecological history.
- Physical examination including general, abdominal, pelvic and vaginal examination as needed.
- Ultrasound examination:
- All sonographic examinations were performed using US machines equipped with low frequency 2D and 3D transabdominal probes.
- 2D ultrasonography including fetal lie, presentation, different biometric measurements (biparietal diameter [BPD], femur length [FL], head circumference [HC] and abdominal circumference [AC]), placental position and grade and amount of liquor and estimated fetal weight were calculated according to the commonly used formula.
- Biparietal diameter
- The BPD was measured as follows: with an axial plane through a symmetrical calvarium, that includes the third ventricle, thalami, falx cerebrum, and cavum septipellicidi anteriorly, and the tentorial hiatus posteriorly. The calipers were placed at the maximal diameter, from the outer edge of the proximal skull wall, to the inner edge of the distal skull.
- Femur Length
- The FL was measured after getting a clear view of both the femoral head and (the greater trochanter) and the femoral condyle (simultaneously-visualized). The cursor was placed at the junction between bone and cartilage, and only the bone is measured.
- Abdominal Circumference
- The AC was measured in an axial plane at the level of portal vein bifurcation (into right and left branches), and the stomach. Measurement was as tight to skin as possible.
- These ultrasonographic parameters were used to confirm normal growth & correct GA corresponding to dates of LMP.
- Hadlock formula represents use of 2D US using BPD, FL & AC in predicting fetal birth weight with a 3.5-MHz transabdominal probe. It was performed using voluson p8
- Fetal weights based on 2D biometry were estimated by using formula from Hadlock et al., [7]
- $\text{Log10 BW} = 1.335 - 0.0034(AC * FL) + 0.0316(BPD) + 0.1623(FL) + 0.0457(AC)$

Three-dimensional ultrasound

- Women were positioned supine for this specialised 3D ultrasound using a 5.0-MHz transabdominal voluson sector transducer. Thigh volume was evaluated using 3D ultrasonography. In the days of 2D biometry, 3D volumes of the thighs were collected. Once the standard orientation of the thigh was determined, the plane was rotated to correctly place the femur in a horizontal position for measurement.
- Multiplanar mode was used to display the 3D dataset, which showed the longitudinal, axial, and coronal portions all at once.
- Plane A revealed the femur in sagittal view, and this picture was rotated such that the thigh and whole diaphysis were seen in a horizontal orientation. As the cursor was moved down the length of the thigh, the appropriate axial planes were shown in Plane B, which had been locked in place. The proximal femoral diaphysis was chosen as the volumetry reference point, and the cursor was moved there.
- After finishing the contouring procedure in Plane B, the thigh was checked for any discrepancies by continuously moving the mouse from one end to the other in Plane A.
- For offline measurement of the fractional thigh volume (TVol), 3D volumes were acquired without foetal movement or compression of the foetal soft tissues, as described by Fractional limb volumetry [10].
- The centre half of the thigh is automatically divided into five evenly spaced sections, and the user traces the sections' outlines in the axial view to form a cylindrical volume. As the cursor in Plane A was advanced toward the femur's distal end, this process was repeated for each successive axial slice that was spaced 3 mm apart.
  - Birth weight (BW) were calculated through the following formula [11]
  - $BW = 604.227 + 34.649\ (\text{Thigh volume})$
  - The EFW obtained with 2D and 3D US was plotted on the growth charts by Yudkin et al. [12], thus obtaining the 2D-US-EFW-Yudkin and the 3D-US-EFW-Yudkin. The EFW percentile was assumed to

be retained from the index growth scan until delivery.

Moreover, both the 2D-US-EFW and the 3D-US-EFW at scan were projected at term using the gestation-adjusted projection (GAP) and the 2D-US-EFW-GAP and the 3D-US-EFW-GAP were computed.

The EFW at birth with either method was compared with the references for birthweight and birthweight centile corrected for gender of the Italian neonatal charts **[13].**

4. All 3D scans were carried out by one investigator.
5. Gestational age at delivery was recorded.
6. Neonatal characteristics were recorded including birth weight which were carried out at the delivery room on the same electronic scale which were done immediately after birth.

3. Results

The age of the patients ranged from (20 to 41) years with (mean ± SD= 29.26 ± 5.443) and BMI ranged from (27.68 to 32.88) kg/m^2 with (mean ± SD= 28.86 ± 0.622). Most of patients were housewives (61%) from rural areas (71%) table (1)

Table (3) Demographic characteristics of the studied patients:

All patients (n= 100)		Mean & SD	Median	Range	IQR
Age (years)		29.26 ± 5.443	29.0	20.0, 41.0	25.25, 33.0
BMI (kg/m^2)		28.86 ± 0.622	28.75	27.68, 32.88	28.49, 29.13
Occupation	**Housewife**	61 (61.0%)			
	Worker	39 (39.0%)			
Residency	**Urban**	29 (29.0%)			
	Rural	71 (71.0%)			

Data is expressed as mean and standard deviation, median, range and interquartile range or as percentage and frequency.

In the current study, there was a positive correlation between actual birth weight and the predicted weight by 2D sonography (Correlation coefficient= 0.837, P < 0.001). Also there was a positive correlation between actual birth weight and the predicted weight by 3D sonography (Correlation coefficient= 0.876, P < 0.001) (table 2).

Table (2) Correlation between actual birth weight, predicted weight by 2D and predicted weight by 3D of the studied patients:

All patients (n= 100)	Correlation coefficient	P
Predicted weight by 2D	0.837	**< 0.001**
Predicted weight by 3D	0.876	**< 0.001**

P is significant when < 0.05.

4. Discussion

Patients' ages varied from 20.0 to 41.0, and their BMIs from 27.68 to 32.88. There was no statistically significant difference (P= 0.883) in the anticipated birthweights from 2D and 3D sonography: (mean SD= 3323.10 298.229) and (mean SD= 3325.50 246.066). However, the actual birthweight (mean SD= 3331.20 232.632) was quite similar to the expected weight (by 3D sonography).

The current investigation found a favourable association between actual and anticipated birthweights for both 2D and 3D (P 0.001).

A research by Ergaz et al. [12] corroborates this finding; they examined 110 individuals between 28 and 41 weeks of pregnancy. Birth weight and both the head and stomach volumes were shown to be positively correlated (r=0.77 and r=0.5, respectively).

The use of 3D methods to describe foetal measures is seldom seen in the literature. Offline 3D foetal reconstruction was employed by Bromley et al. [13] in the third trimester. As a result of their research, the scientists determined that this strategy accurately predicts foetal weight. It has been shown by Yang et al. [14] that 3D ultrasound provides for quicker foetal measuring times than 2D ultrasound, even when performed by an unskilled operator.

When comparing the 3D fractional thigh volume (TVol) method to the traditional 2D method for estimating birth weight in pregnant women with gestational diabetes mellitus (GDM), Pagani et al. [15] found that the 3D method was more accurate in predicting the birth weight of babies born to women with GDM (Hadlock). During the trial, 125 pregnant women with GDM were screened by ultrasonography between weeks 34 and 36. They came to the conclusion that 3D fractional TVol readings were more accurate than the conventional approach based on Hadlock's formula in estimating the newborn's real weight. When comparing the TVol approach to the Hadlock method for predicting newborn macrosomia, we find that it is equally sensitive but more specific.

Tuuli et al. [16], who assessed 115 pregnant women with gestational or pregestational diabetes who gave birth after 38 weeks using 2D and 3D sonography, found the opposite to be true. Using the gestational age adjusted projection approach, they discovered that the Hadlock 2D formula was more accurate in predicting birth weight and macrosomia in diabetes mothers when employed about 2 weeks before to delivery. This may be because inadequate glycemic control violated an assumption made by the gestational-weight-projection-method used to predict birth weight, which states that the ratio of actual foetal weight to the median foetal weight at the same gestational age remains constant during the third trimester.

Kang et al. [17] analysed data from a sample of 211 women who had just one pregnancy (28–42 weeks). Two-dimensional ultrasonography was used to quantify foetal AC, whereas the 3D limb volume approach was used to measure the fetus's upper arm (AVol)/ TVol. The findings demonstrated that the multivariate linear model's estimated foetal weight was more in accordance with the actual foetal weight at delivery. P values of 0.314 and 0.477 for the model and Hadlock formulae' predictions vs the actual birth weight find no statistically significant difference. Researchers found that a model for predicting foetal weight based on the combination of semi-automatic 3D limb volume and AC had good accuracy, sensitivity, and specificity. For the diagnosis of macrosomia in particular, the prediction model formula demonstrates improved predictive performance.

In addition, Gibson et al. [18] studied prenatal populations suspected of having macrosomia and showed that TVol gives the most accurate prediction of both the babies' body fat percentage and birth weight. Findings demonstrated high sensitivity and specificity for TVol.

Several variables affect foetal development, including genetics, mother characteristics (such as nutritional age and pregnancy problems and illnesses), environmental factors (such as maternal smoking and drug use), and environmental and socioeconomic factors. Examination circumstances in late pregnancy, the presence of an aberrant foetus, and the difficulty in getting exact measurement section all contribute to a less than reliable evaluation [19].

O'Connor et al. [20] used 3D ultrasonography, foetal biometry, and soft tissue thickness to evaluate fractional thigh volume (TVol) in 42 mother-infant pairs. TVol was shown to have a significant correlation with birth weight in a linear regression study. Also linked to lean body mass at birth was 33-week TVol.

In a prospective study utilising 2D and 3D ultrasonography performed within 5 days after birth, Yang et al. [21] investigated healthy late third-trimester foetuses. Regular foetal biometric measurements were taken using 2D ultrasound, while 3D ultrasound was used to measure fractional TVol and midthigh circumference. The highest accurate birth-weight estimate was achieved with the prediction model using TVol, femur length (FL), abdominal circumference (AC), and biparietal diameter (BPD), with a random error of 4.68% and R2 of 0.825. Up to within 5% and 10% of the actual birth weight, it accurately predicted 69.5 and 95.3% of birth weights, respectively. The Hadlock model using conventional foetal biometry (birth weight, placental size, abdominal circumference, and foetal length) resulted in a random error of 6.41 percent. In 46.3% of cases, the predicted birth weight was within 5% of the actual birth weight, and in 82.6% of cases, the predicted birth weight was within 10% of the actual birth weight.

In a study using 3D sonography, Srisantiroj et al. [22] evaluated 176 pregnant women who met the criteria (TVol). Based on their findings, they determined that the 3D-fractional TVol of a foetus correlates well with the actual birthweight of the baby. Predictions of the foetal weight may be more reliable if the fractional TVol is measured in certain circumstances.

5. Conclusion

Predictions of the foetal weight may be more reliable if the fractional TVol is measured in certain circumstances. Measurements of fractional limb volume may be used to assess foetal size and growth at various stages of pregnancy, and future quantitative investigations should provide light on this topic. Exploring the best birth weight algorithm that adds TVol into conventional birth weight formulas requires large prospective research. Before this indicator may be used in clinical practise, further prospective studies are needed to determine whether or not soft tissue alterations, as measured by TVol, are associated with foetal growth limitation or macrosomia.

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