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CONTEMPORARY STUDY

Predictability of Fetal Birth Weight from Measurement of Fetal Thigh Circumference by Two-dimensional Ultrasound: A Prospective Study

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ABSTRACT

Objective: The aim of this study was to compare the predictability of the Vintzileos' formula with the Hadlock's formula in estimating the fetal weight nearest to the actual birth weight.

Methods: It was a prospective observational study conducted with 138 antenatal mothers with single viable fetus and no major congenital abnormalities. A two-dimensional ultrasound scan was performed between 38 and 40 weeks gestation, which measured the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) and thigh circumference (TC) at the level of midthigh, and incorporated them to estimate fetal weight using the Hadlock's and the Vintzileos' formulae.

Results: For the majority of the study population (63.04%), the mean fetal weight estimated by the Vintzileos' formula was nearer to the mean actual birth weight compared to the Hadlock's formula. There was strong correlation (Karl Pearson's correlation coefficient r = 0.98, p-value <0.05) between the sonologically estimated and the neonatal thigh circumference.

Conclusion: The results of this study show 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.

Keywords: Predictability, Birth weight, Fetal thigh circumference.

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INTRODUCTION

Intrauterine growth restriction and macrosomia are not uncommon in obstetrics and carry an increased risk of perinatal mortality and morbidity. Estimation of fetal weight is crucial because proper evaluation and management can result in a favorable outcome. To date, two-dimensional ultrasound (2-D US) becomes an essential tool for fetal weight estimation. In this study, we present our experience regarding the usefulness of incorporating fetal thigh circumference measurements in ultrasound fetal weight estimation formulae for the prediction of birth weight. Two ultrasound formulae—the Hadlock's formula and the Vintzileos' formula—have been compared, of which the second one has the fetal thigh circumference incorporated as a biometric parameter. We tried statistically, to compare the predictability of the Vintzileos' formula with the Hadlock's formula in estimating the fetal weight nearest to the actual birth weight, and also to find out the degree of correlation between the US and postnatal thigh circumference to justify its importance in estimation of fetal weight.

METHODS

It was a prospective observational study, performed in the Department of Obstetrics and Gynecology with the help of the Department of Radiodiagnosis, IPGME&R, Kolkata, conducted between April 2009 and March 2010. The study population comprised antenatal mothers attending the Outpatient Department of Obstetrics and Gynecology, IPGME&R, and subsequently getting admitted for safe confinement. The sample size of the study population was 138, which included consecutively enrolled antenatal mothers with single viable fetus. Twin pregnancies or pregnancies with higher order of gestation, major congenital anomalies and more than 4 weeks discrepancy between gestational age calculated from the last normal menstrual period and dating USG scan were excluded from the study.

After performing a first trimester dating and then an anomaly scan, a 2-D transabdominal ultrasound scan was performed between 38 and 40 weeks, approximately a week prior to delivery. This scan measured the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) and thigh circumference (TC) and incorporated them to estimate the fetal weight using two formulae. The first formula was the Hadlock's formula, which does not use thigh circumference as a parameter. The formula is as follows:

$$\text{Log (Expected fetal weight)} = 1.487 - 0.003343 \times AC \times FL + 0.001837 \times BPD \times BPD + 0.0458 \times AC + 0.158 \times FL.$$

The second formula used was the Vintzileos' formula, which uses the fetal thigh circumference as a parameter. The formula is as follows:

$$\text{Log (Birth weight)} = 1.897 + 0.015 \times AC + 0.057 \times BPD + 0.054 \times FL + 0.011 \times TC.$$

The mothers were followed up till delivery. If they did not deliver within one week of the third trimester scan, the scan was repeated and the fetal weights using the two formulae were reestimated. Within half an hour of delivery, the neonates were weighed on a weighing scale, which was compared with the sonologically estimated fetal weight. The thigh circumference of the neonate was measured at the middle of the thigh with a measuring tape for comparison with ultrasound measurements. For measuring the thigh circumference, the whole length of the femur from the greater trochanter to the distal metaphysis was visualized on the ultrasound monitor. The transducer was then rotated by 90° to obtain a cross-sectional profile of the

middle of the thigh at a position where the cross-section of the femur bone remained equidistant from the soft tissue around it and the boundary of the thigh profile was well defined. The thigh circumference was determined with elliptical approximation three times and then the average was taken as the final measurement. This measurement was done in accordance with previous studies done by Hebbar et al.[1]

RESULTS

Data were analyzed using Microsoft Excel 2003 and the statistical software used was Statistica Version 6 [Tulsa, Oklahoma: StatSoft Inc 2001]. After birth, the neonates were categorized into four birth weight categories as shown in Table 1. This table shows that for birth weight categories 1 and 4, the mean weight estimated by the Hadlock's formula was slightly closer to the mean of the actual birth weight. The difference, however, was not statistically significant. In the other two categories, the mean fetal weight estimated by the Vintzileos' formula was nearer to the mean of the actual birth weight. The majority (63.04%) of the study population belonged to these two groups. However, the population distribution in each group was not equal, and the sample size of category 4 was small in comparison to other groups.

In our study, the mean USG estimated thigh circumference and actual thigh circumference measured after birth were 136.77 and 146.59 mm respectively, as shown in Table 2, indicating that the difference was small and Karl Pearson's correlation coefficient (r-value) was 0.98. The correlation coefficient between the actual birth weight and the fetal weight estimated by the Hadlock's formula was 0.94, whereas with the Vintzileos' formula, r-value was 0.95. All these correlation coefficients were significant at the level of p-value <0.05. These results show a strong correlation between the actual and estimated thigh circumference, and between the actual and estimated fetal weight by both formulae (Correlation coefficient values: ≥0.7 implies strong correlation).

The ability of Hadlock's and Vintzileos' formulae to correctly predict birth weight within ±10% of actual in different birth weight categories is shown in Table 3. This table shows that as the birth weight increased, the ability of both formulae to predict birth weight within ± 10% of actual also increased. In birth weight categories 3 and 4, the predictability of Vintzileos' formula was 100%. However, prediction was least accurate in category 1. The level of significance as noted by the Chi-square p-value in category 1 was <0.05, while it was <0.001 in category 2,3 and 4.

The comparative analysis of FL/TC ratio in birth weight category 1 and the difference between the actual birth weight and birth weight estimated by the two ultrasound formulae (mean values) combining all four categories is shown in Table 4. From this table, it was seen that the 95% confidence range of the FL/TC ratio in birth weight category 1 was from 0.61 to 0.633, and the standard deviation in this category was 0.04. Hence, an FL/TC ratio greater than 0.633 can be taken as an indicator of intrauterine growth restriction in our study. Combining all the four categories, the mean difference between actual and estimated fetal weights was more for Hadlock's formula than the Vintzileos' formula (195.63 *vs* 145.64).

The Mc Nemar Chi-square test was used in calculating the difference between Hadlock's and Vintzileos' formulae in

Table 1: Comparative analysis of mean actual birth weight with mean fetal weight sonologically estimated by two formulae in four different birth weight categories (n = 138)

Birth weight category	*≤2500 gm (CAT 1)*	*2501-3000 gm (CAT 2)*	*3001-3500 gm (CAT 3)*	*>3500 gm (CAT 4)*	*Overall*
Number (n)	37 (26.81%)	64 (46.37%)	23 (16.66%)	14 (10.15%)	138
Mean actual weight (gm)	2082.67	2750.95	3140.21	3738.00	2736.79
Mean EFW Hadlock (gm)	2234.32	2880.39	3234.78	3803.21	2859.85
Mean EFW Vintzileos (gm)	2265.92	2776.58	3197.74	3197.74	2810.02

CAT: Category, EFW: Estimated fetal weight

Table 2: Comparative analysis of estimated and actual thigh circumference as well as estimated and actual birth weight by Hadlock's and Vintzileos' formula with their correlation coefficient (n = 138)

Method	*Mean (min – max)*	*SD*	*SE*	*Correlation coefficient (r)*	*p-value*
Estimated TC (mm)	136.77 (113-166)	11.69	0.99	0.98	<0.05
Actual TC (mm)	146.59 (120-175)	11.65	0.99		
Actual weight (gm)	2736.79 (1756-3900)	520.43	44.30	0.94	<0.05
EFW Hadlock's method (gm)	2859.86 (1892-4152)	518.63	44.15		
Actual weight (gm)	2736.79 (1756-3900)	520.43	44.30	0.95	<0.05
EFW Vintzileos' method (gm)	2810.02 (1650-4000)	485.31	41.31		

Min: Minimum, Max: Maximum, TC: Thigh circumference, SD: Standard deviation, SE: Standard error, EFW: Estimated betal weight

correct prediction of birth weight to within 10% of actual. This is shown by Table 5. McNemar's test 2 tailed p-value for all four categories combined was 0.424, whereas for birth weight category 1, the p-value was 0.774, and for birth weight categories 2,3 and 4 combined, it was 0.092. This implies that in category 1, the Vintzileos' formula is comparable to the Hadlock's formula in its ability to predict birth weight within 10% of actual, while its predictability is definitely better in categories 2, 3 and 4.

DISCUSSION

Our study shows that an ultrasound formula like the Vintzileos' formula that incorporates the thigh circumference of the fetus as a biometric parameter in addition to BPD, AC, and FL as used by the Hadlock's formula, can be used successfully to estimate fetal weight in a standard Indian population as an alternative to the Hadlock's formula. Combining all four categories, the mean fetal weight estimated by the Vintzileos' formula (2810.02 gm) was nearer to the mean actual birth weight (2736.79 gm), compared to the mean fetal weight estimated by the Hadlock's formula (2859.86 gm). Our study is comparable to the study conducted by Vintzileos et al,[2] who incorporated the fetal thigh circumference in addition to measurements of the head, abdomen and femur length to improve the accuracy of fetal weight estimates.

Our study showed that estimated fetal birth weights using thigh circumference correlated well with the actual birth weights in all categories and was superior to the Hadlock's formula. There was a good correlation between ultrasound measurement and the actual postnatal measurements of the thigh circumference ($r2 = 0.98$, $p < 0.05$). Also, the FL/TC ratio greater than 0.633 based on our study was taken as an indicator of IUGR. The results of this study indicated that fetal thigh circumference measurements can add further to the accuracy of birth weight estimation in obstetric practice, which is comparable to the study by Hebbar S et al.[1]

In order to eliminate the interobserver errors in estimation of fetal weight, only single observer readings by ultrasound were taken into account in our study.

Saqib R et al[3] measured fetal thigh circumference at the junction of the upper and middle third of the femur, at the level of the nutrient foramen of the femur, though in our study, the level of measurement of the fetal thigh circumference was at the level of mid thigh.

One study[4] tried to compare the accuracy of three-dimensional (3D) ultrasound-assessed fetal thigh volumetry in predicting birth weight with that of other commonly used formulas composed of the BPD, AC, and FL by two-dimensional (2D) ultrasonography. The thigh volume assessed by 3D ultrasonography was highly correlated with birth weight ($r = 0.414$, $n = 100$, $p < 0.0001$). However, in our study, two-dimensional measurement of all parameters was done as the 2D USG machine is most commonly available in our set-up and gives a reasonably good result in predicting birth weight.

Another study[5] using fractional thigh volume (ThiV) to predict birth weight shows a high correlation ($r = 0.965$) between ThiV and birth weight and better inter- and intraobserver reliability. However, it needs a specialized ThiV measurement technique, which requires a sophisticated training program of the radiologists to make it acceptable on a large scale.

It was difficult to delineate the point of maximum muscle mass of the thigh and to radiologically visualize the midpoint

Table 3: The ability of Hadlock's and Vintzileos' formula to correctly predict birth weight within ± 10% of actual in different birth weight categories

Birth weight category	*Had 10% incorrect*	*Had 10% correct*	*Vin_10% incorrect*	*Vin_10% correct*	*p-value*
1	n = 15	n = 22	n = 17	n = 20	<0.05
%	40.54%	59.46%	45.95%	54.05%	
2	n = 9	n = 55	n = 3	n = 61	<0.001
%	14.06%	85.94%	4.69%	95.31%	
3	n = 1	n = 22	n = 0	n = 23	<0.001
%	4.35%	95.65%	0.00%	100.00%	
4	n = 0	n = 14	n = 0	n = 14	<0.001
%	0.00%	100.00%	0.00%	100.00%	
Total	25	113	20	118	

Had/Vin_10% correct/incorrect—Percentage of fetuses whose birth weight was correctly/incorrectly predicted within ±10% of actual by Hadlock's/Vintzileos' formula

Table 4: Comparative analysis of FL/TC ratio in birth weight category 1 and difference between the actual birth weight and sonologically estimated birth weight (mean values) combining all four categories

Estimated parameter	*Mean*	*CI –95%*	*CI +95%*	*SD*	*SE*
FL/TC ratio in category 1 (n = 37)	0.62	0.61	0.633	0.04	0.01
ACT – Had (n = 138)	195.63	211.31	189	93.13	7.93
ACT – Vin (n = 138)	145.64	162. 4	118	99.96	8.51

CI –95% and CI +95%—The 95% confidence intervals

ACT – HAD/ACT –VIN—Difference between mean actual birth weight and mean fetal weight estimated by the Hadlock's/Vintzileos' formula

Table 5: The difference between Hadlock's and Vintzileos' formulae in correct prediction of birth weight to within 10% of actual

Birth weight category	*McNemar's 2-tailed p-value*
Overall (n = 138)	0.424
Category 1 (n = 37)	0.774
Category 2, 3 and 4 combined (n = 101)	0.092

of the thigh when there was oligohydramnios. If the thighs of the fetus were acutely flexed on the abdomen, the entire thigh circumference often became difficult to delineate completely. In case of large babies, belonging to category 4 of birth weight, the fetal limbs were often difficult to delineate separately, as the fetal abdomen frequently came in the way of the view while trying to capture the sonologic image of the fetal limbs.

CONCLUSION

It can be concluded, based on this small study on 138 babies, that fetal thigh circumference has a role to play in accurately measuring fetal weight when incorporated with other fetal parameters. The Vintzileos' formula has better predictability in estimating fetal weight compared to the Hadlock's formula. There is a scope of using the FL/TC ratio in predicting IUGR *in utero.* With the emergence of four-dimensional ultrasound and MRI for predicting birth weight, only time will tell whether these tools have a better accuracy than two-dimensional and three-dimensional ultrasound in predicting birth weight.

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