ESTIMATION OF FOETAL WEIGHT IN THIRD TRIMESTER USING THIGH MEASUREMENTS

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Background: Estimation of foetal weight is essential in daily obstetric practice particularly close to term. It guides clinicians to finalize important obstetrical decisions. Low birth weight and excessive foetal weight at delivery both are associated with an increased risk of neonatal complications during labour and the puerperium. The objectives of this cross sectional study were to estimate the foetal weight using only two thigh parameters and its comparison with birth weight. This study was conducted in Radiology Department PNS Shifa during 1st June, 2007 to 30 Nov, 2007. **Methods:** All pregnant females coming to Radiology Department for Ultrasound examinations in 3rd trimester were the Subjects of study. All infants were delivered with in 48 hour of ultrasound examination.100 patients were included in this study. Thigh measurements were made by conventional two-dimensional ultrasonography. The Isobe formula was compared with already established Aoki's formula and actual birth weight using paired sample *t*-test. **Results:** Isobe's formula showed a significant correlation with the actual birth weight. In 90% of cases estimated foetal weight was within 10% of the actual birth weight **Conclusion:** The Isobe's formula was found to be convenient among all the established formulas for estimated foetal body weight. Measurement of head circumference was not necessary near term.

Keywords: Ultrasonography 3rd Trimester, Estimated Foetal Body Weight, Birth Weight, Thigh.

INTRODUCTION

Estimation of foetal weight is essential in daily obstetric practice particularly close to term. It guides clinicians to finalize important obstetrical decisions. Low birth weight and excessive foetal weight at delivery both are associated with an increased risk of neonatal complications during labour and the puerperium.[1,2, 3]

Depending on many factors, the optimal range for birth weight is thought to be 3,000–4,000 grams. Various formulas to calculate EFBW (Estimated Foetal Body Weight) were used in daily clinical practice.[4] The limitations and sensitivity of these formulas had been investigated.[5] Patrick and colleagues[5] studied the validity of four major formulas; those of Aoki[6], Campbell and Wilkin[7], Shepard and colleagues[8] and Hadlock and colleagues[9]. As a result they recommended Aoki's formula as the most accurate in calculating EFBW.[5]

The majority of the commonly used formulas for estimating foetal weight include measurements of the head circumference, abdomen diameter and femur length, alone and in combination. The value of the foetal thigh circumference measurement in addition to the head, abdominal, and femur length measurements has been investigated.[10] It was found that the addition of thigh circumference to measurements of the head, abdomen, and femur length improves the accuracy of foetal weight estimates. Formulas for estimation of foetal weight, using thigh circumference measurement and abdominal measurement, without head measurement had been previously presented by Hohler and associates.[11] Recently, it was reported that three-dimensional measurements could improve the accuracy of foetal weight estimation.[12]

EFBW is needed especially when head measurement is impossible, because the foetal head is positioned low in the pelvic cavity. A convenient method for estimating foetal body weight without head measurement was thus required. In our setup most of the ultrasound machines used, were two dimensional so there is a need to drive a formula, which is simple and accurate, using conventional, two dimensional, ultrasonography. Isobe derived a formula from only thigh measurements.[13] The newly derived formula was quite simple, involving only two thigh parameters while using conventional, two dimensional ultrasonography without the need for head measurement.

The purpose of this study was to check the validity of Isobe's formula by estimating foetal weight with this formula and comparing it with Aoki's formula and birth weight.

PATIENTS AND METHODS

The study was conducted in Department of radiology, PNS Shifa Hospital Karachi, which is one of the largest referral hospitals for Armed forces personnel and their families. Total duration of study was 6 months, starting from 1st June 2007 to 30 Nov 2007. Pregnant ladies coming to Radiology Department for Ultrasound examination in 3rd trimester were the Subjects of study. One hundred pregnant women with a singleton foetus who were delivered within 48 hour of an ultrasound examination and those without structural anomalies were included in the study. Patients with breech presentation, twin pregnancy and oligohydramnios were excluded from the study because exact foetal thigh circumference is difficult to obtain in these patients owing to the blurring of the echographs and the deformation of the foetal thigh circumference under compression.

Data collection was prospective and specifically for the purpose of this study. An informed consent was obtained from all patients prior to carrying out the procedure. All measurements were performed by the same operator using a trans-abdominal ultrasound with 5.0 MHz convex probe (Nemio, Toshiba, Japan). Each foetus was examined on a single occasion and only single readings were used. Gestational age determined from the last menstrual period and confirmed by ultrasound, was given in exact weeks. As parameters Biparietal diameter (BPD), Abdominal Circumference (AC), Femur length (FL) and Cross sectional area of thigh (CSAT) was taken.

BPD measurements were taken from the outer edge of the proximal foetal skull bone to the outer edge of the distal bone. The transverse diameter and circumference of the foetal trunk were measured in standard transverse planes at the level of the stomach and umbilical vein-ductus venosus complex. The FL was measured from the proximal end of the greater trochanter to the distal metaphysis. The CSAT is defined as the cross sectional area of the muscles and bones of the thigh on the plane at right angle to the long axis of the femur, where the area is the largest. The method used to measure CSAT was as follows. The FL was first measured, then the probe was inclined so as to be at right angles to the long axis of the femur and moved quickly along its surface. At the point where the cross-sectional area of the muscles and the bone of the thigh reached its maximum, the probe motion was stopped. The area was then measured using the ellipse function.

Measurement for foetal thigh circumference were recorded at transverse plane at the junction of the upper and middle thirds of the thigh, at the level of the proximal nutrient foramen of the femur[14](Figure-1). Measurements made within 1–2cm of the transition plane are quite similar, demonstrating that exact positioning of the plane is not necessary. By comparing the portion of Figure 1 with the anatomical structures corresponding to that position in the plane where the cross-sectional area perpendicular to the long axis of the muscles and bone of the thigh is largest, four hyperechogenic images are seen to be characteristic of the echogram. In an anatomical study, these hyperechogenic images are thought to indicate the femoral bone and the tissues between the muscles (vastus, rectus, biceps and adductor) as shown in Figure 2. In the present study, the cross-sectional area of the muscles and bone of the thigh on the plane where these typical hyperechogenic images could be detected was assumed to be the CSAT.

The estimated foetal birth weight (EFBW) was calculated using the following formula:’

$$EFBW = 13 \times (FL \times \sqrt{CSAT}) + 39 \text{ (gm)}$$

The birth weight (BW) of the infant was done immediately after delivery.

Statistical analysis was performed on a personal computer using SPSS (for windows Version 10). The data from the study was evaluated by comparing the results of EFBW and BW, taking BW as the gold standard. Differences among estimated weights from the Isobe formula, Aoki’s formula, and the actual birth eight were assessed by a paired t test.

The percentage of cases in which the estimated foetal weight was within 10% of the actual birth weight was calculated on the basis of both the derived formula and Aoki’s formula.

In addition, an evaluation was carried out by comparison of the correlation coefficients in scattergrams of the actual birth weight versus the predicted birth weight from Aoki’s formula and Isobe’s formula. A p value of <0.05 was considered statistically significant.

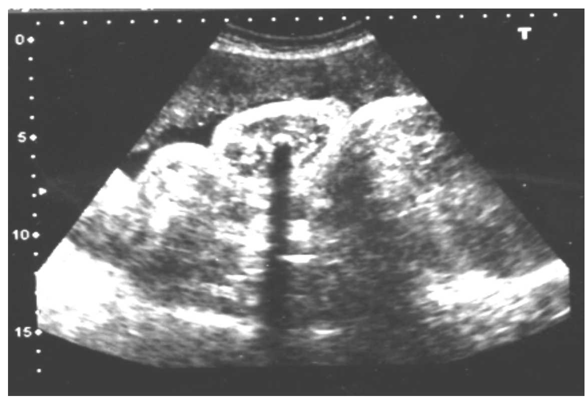

Figure-1: Sonographic views of the cross-sectional area of the thigh at right angles to the long axis, at the junction of upper and middle third of thigh.

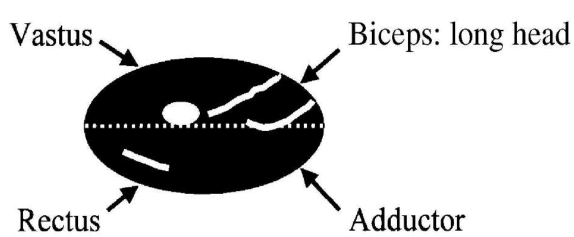

Figure-2: Echographic features in the plane of the largest cross sectional area perpendicular to the long axis of the thigh. Four hyperechogenic portions are thought to indicate femoral bone and tissues between muscles (vastus, rectus, biceps and adductor)

RESULTS

Data characteristics of study population are shown in Table-1 as demographic data. Mean age of patients was 27 years where as mean gestational age was 38 weeks. Eighty-two were multiparous while 18 were primiparous. Mean values and standard deviations of FL and CSAT were 71±3.3 mm and 11.1±1.9 cm respectively.

Birth Weight Characteristics of Study Population are shown in Table-2. The percentage of cases in which the estimated foetal weight was within 10% of the birth weight was 90% (90/100) with the Isobe's formula, and 91% (91/100) with Aoki's formula. There was no statistically significant difference between the two formulas ($p<0.05$).

Comparison of foetal weights with Aoki and Isobe's Formula with birth weight was done using paired sample *t*-test as shown in Table-3. The estimated foetal weight from Aoki's formula and that from the Isobe's formula showed no statistically significant differences from the birth weight examined by a paired *t*-test. Also there was no statistically significant difference between the estimated weight from Aoki's formula and that from the Isobe's formula.

The scatter-gram of birth weight versus predicted foetal weight from Aoki's formula is shown in Figure-3. The Correlation coefficient is 0:932. The scatter-gram of the birth weight versus the predicted foetal weight from the Isobe's formula is illustrated in Figure-4. The correlation coefficient is 0:910.

Table-1: Demographic Data of Study Population

	Minimum	Maximum	Mean	SD
Age of patient (yrs)	18	42	27.56	4.64
Gestational age (wks)	32.5	40.5	38.441	1.607
Biparietal diameter (mm)	78.10	95.80	89.4160	3.5538
Abdominal circumference (mm)	275.50	380.10	330.546	22.618
Femur length (mm)	56.80	76.00	71.0390	3.3460
Cross sectional area of thigh (cm)	6.04	14.85	11.1812	1.9656

Table-2: Birth Weight Characteristics of Study Population

	Minimum	Maximum	Mean	SD
Foetal weight with Aoki formula (g)	1749	3846	3032.91	426.86
Estimated foetal birth weight with Isobe formula (g)	1887	3826	3122.39	381.72
Birth weight (g)	1780	4180	3118.45	433.66

Table-3: Comparison of birth weights with Aoki and Isobe's Formula with actual birth weight using paired sample *t*-test

		Mean±SD	SEM	*p*
Pair 1	Foetal weight with Aoki formula	3032.91 ±426.86	42.68	0.0
	Birth weight	3118.45 ±433.66	43.36	
Pair 2	Foetal weight with Isobe formula	3122.39 ±381.72	38.17	0.0
	Birth weight	3118.45 ±433.66	43.36	

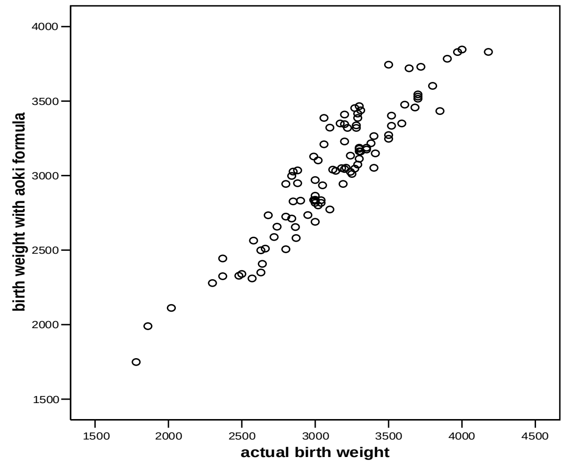

Figure-3: scatter-gram of the birth weight versus the predicted foetal weight from Aoki's formula

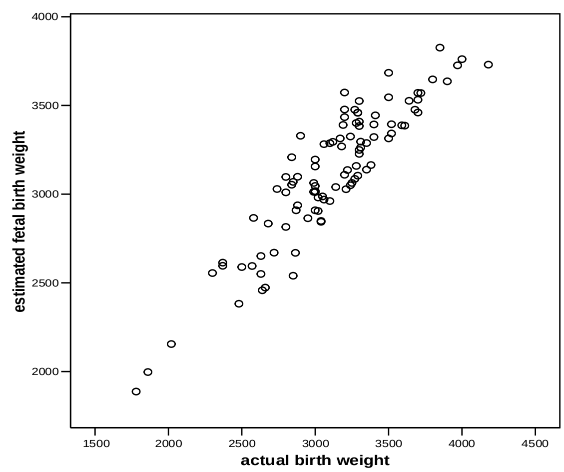

Figure-4: The scatter-gram of the birth weight versus the predicted foetal weight from the Isobe's formula

Scattergram showing the correlation etween actual and predicted birth weights calculated by Isobe's formula n=100; correlation coefficient=0.910.

DISCUSSION

Both low birth weight and excessive foetal weight at delivery are associated with an increased risk of newborn complications during labour and the puerperium. Improvements in perinatal and neonatal care have led to a reduction in foetal mortality and morbidity, with survival chances of growth retarded foetuses improving with advancing gestational age.

Inaccuracy in foetal weight estimation arises from two sources. The most obvious is the observational error in the measurement of biometric variables. The second arises from limitations of the weight formula for combining these variables (method error). One study suggested that a considerable portion of error in foetal estimation arises from the intrinsic properties of the ultrasound formula rather than the accuracy of the input biometric data. Thus method error could be reduced by designing better weight estimation formulae, particularly if these have been derived from local population.[15] Further work to improve the universal validity and accuracy of foetal weight estimation formulae was thus required.[16]

Most of the commonly used formulae for estimating foetal weight use multiple measurements of the foetus. These multiple measurements enhanced accuracy slightly. The extra time involved in performing these measurements is therefore unrewarding. We used only two thigh measurements to estimate foetal weight. Moreover in our study only single observer readings were used because measurements by multiple examiners changes only slightly, the average number of discrepancies between estimated and actual foetal weight.[17]

The majority of the commonly used formulae for estimating foetal weight include measurements of the head, abdomen and femur both alone and in combination. None of these formulae pays attention to the soft tissue mass of the foetus. However, since foetal weight depends not only on head and body dimensions but also on extremity size, it seems reasonable to investigate the role of other body measurements in improving foetal weight estimates.

Hoffbauer and co-workers were among the first to include foetal thigh diameter in a weight formula. They draw the conclusion that circumference measurements of foetal thigh could be made in a reliable manner and could be used to detect changes in the soft tissue mass and possibly improve foetal weight estimation.[9] In an attempt to further improve foetal weight estimation Vintzileos and colleagues performed a step wise polynomial regression analysis including foetal thigh circumference. The best results were obtained by combing measurements of standard 2D parameters and thigh circumference.[10] Lee W and workers[18] introduce the fractional thigh volume as a new soft tissue parameter for foetal growth evaluation and define its relationship to menstrual age. Cutaneous and subcutaneous limb circumference proved to be better predictors of actual weight at birth than abdominal circumference. Thus thigh circumference formulae might be helpful in improving the accuracy of foetal weight estimates in growth restricted and macrosomic foetuses which have quantitative disturbances in the soft tissue mass.[12]

Recently Isobe derived a formula from only thigh measurements[11]. We used this formula in our study to estimate foetal body weight. The newly derived formula is quite simple involving only two thigh parameters while using conventional, two dimensional ultrasonography, without the need for head measurement. EFBW is needed especially at term when head measurement is impossible, because the foetal head is positioned low in the pelvic cavity. This results in erroneous foetal weight estimation with formulas using BPD. Isobe's formula does not involve head measurements.

Previous studies measure the cross-sectional area of thigh from outside of the skin including the fat pad in the thigh. However, the cross-sectional area of the muscles and bone of the thigh was measured in the present study because measuring from the outer edge of the skin is virtually impossible due to the blurring of the borderline sonographically. The value of FL×CSAT indicates the volume of a cylinder corresponding to the circumference of the thigh, and serves as an approximation of the volume of the thigh. The value of FL × square root of CSAT indicates the surface area of the cylinder corresponding to the circumference of the thigh, and serves as an approximation of the surface area of the thigh. The formula is:

$$EFBW = 13\times(FL\times\sqrt{CSAT})+39 \text{ gram}$$

Estimation Error: ±250 g

We used Aoki's formula as a control because it has already been validated using various methods to date and has been recommended as the most accurate in calculating EFBW.[5] The birth weight of the infant was done immediately after delivery and taken as gold standard.

The validity of this newly derived formula was investigated by Isobe T in 58 cases. The percentage of cases in which the estimated foetal weight was within 10% of the actual birth weight was 81.03% (47/58) with the derived formula, and 86.21% (50/58) with Aoki's formula. We investigated the validity of Isobe's formula in 100 cases. The percentage of cases in which the estimated foetal weight was within 10% of the actual birth weight was 90% (90/100) with the Isobe's formula, and 91% (91/100) with Aoki's formula. The correlation coefficients in Isobe's study were 0.879 with the Isobe's formula and 0.909 with the Aoki's formula. Where as the correlation coefficients in our study were 0.910 with the Isobe's formula and 0.932

with the Aoki's formula. Therefore our study yielded favourable results in support of Isobe's formula.

CONCLUSION

The Isobe's formula in this study would be useful in daily clinical practice for estimation of foetal weight, especially in cases in which head measurements are impossible. It would help the obstetrician in early diagnosis of IUGR and macrosomia and prevention of potential complications associated with these two conditions. It would be convenient among all the formulas involving only two thigh parameters while using conventional, two dimensional ultrasound examination for foetal weight estimation without the need for head measurement near term.

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