Malaysian Journal of Obstetrics & Gynaecology
2005: Vol. 8, No. 9: 13-23

ROLE OF FETAL THIGH CIRCUMFERENCE IN ESTIMATION OF BIRTH WEIGHT BY ULTRASOUND

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ABSTRACT

OBJECTIVE: *To evaluate the accuracy and usefulness of predicting birth weight by measuring fetal thigh circumference by ultrasound.*
METHODS: *In 110 pregnant women, fetuses without structural or chromosomal anomalies were studied prospectively and cross-sectionally. Thigh circumference (TC) was determined at the mid level of the thigh. Biparietal diameter (BPD), Head circumference (HC), Abdominal circumference (AC), and Femur length (FL) were measured using standard techniques. Fetal weights were estimated within a week prior to delivery. Statistical analysis of various ultrasound birth weight formulae in different weight categories was done and compared with each other and also with clinical methods.*
RESULTS: *Estimated fetal birth weight using TC correlated well with actual birth weights in all categories and was superior to clinical and birth weight formulae using BPD, HC, AC and FL measurements.*
CONCLUSIONS: *There was a good correlation between ultrasound measurement and actual postnatal measurements of thigh circumference (r2=0.89, p<0.01). Thigh circumference measurement was simple and there was better accuracy when it was combined along with BPD, HC, AC and FL measurements.*
(Keywords: Estimated Birth Weight, Thigh Circumference)

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INTRODUCTION

As far as independent extrauterine existence and optimum survival of foetus is concerned birth weight is undoubtedly one of the most significant determinants of neonatal survival. It has become increasingly important especially for the prevention of prematurity, evaluation of pelvic disproportion before induction of labor and detection of Intra Uterine Growth Restriction (IUGR).

Many studies have been undertaken 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 measured at the level of umbilicus. But they are subjected to significant margin of error and are not useful in malpresentations, maternal obesity, multifetal pregnancy, polyhydramnios and oligohydramnios. Ultrasound uses many fetal parameters such as Biparietal diameter (BPD), Head circumference (HC), Abdominal circumference (AC), Femur length (FL). This method is better compared to clinical methods and more reproducible (Deter et al, 1982; Hadlock et al, 1985; Vintzileos et al, 1987).

It is very well known that decrease in liver size and hence decreased abdominal circumference is the most important distinguishing characteristic feature of asymmetric IUGR (Vintzileos et al, 1987). Other features like scrawny limbs (because of decreased muscle mass) and thinned skin (because of decreased fat) lead to decrease in thigh circumference which also can be measured by ultrasound. However many standard ultrasound fetal birth weight models do not incorporate thigh measurements which may be proven most useful in predicting fetal weight when growth abnormalities are present. Many pediatricians use postnatal thigh circumference to screen low birth weight babies as it serves as one of the important indicators of soft tissue mass (Mattoo GM et al, 1991).

Vintzileos et al (1987) 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 that the addition of thigh circumference to measurements of the head, abdomen, and femur length improves the accuracy of fetal weight estimates.

Balouet P et al (1994) investigated value of thigh circumference measurement in addition to other ultrasound parameters (BPD, AC & FL) in diagnosis of small for age fetuses and found that there was significant improvement in fetal weight prediction (mean error with TC was 6% compared to 10% for most of the classical models). They also opined that TC is a best trophicity parameter compared to AC and including it in routine ultrasound biometry may facilitate early diagnosis of IUGR.

Unfortunately, there were very few studies in the past to validate role of TC in prediction of birth weight. In the current study, we present our experience regarding usefulness of incorporating fetal thigh circumference measurements in ultrasound fetal weight estimation formulae in prediction of birth weight. Two ultrasound formulae (Hadlock et al, 1985 and Vintzileos et al, 1987) and two clinical formulae (Johnson R.W, 1957 and Insler, 1967) have been compared. Hadlock's method is the most popular formula which uses BPD, AC and FL and is inbuilt in all ultrasound machines. Vintzileos model uses TC measurements in addition to BPD, AC and FL.

MATERIALS AND METHODS

It is a prospective study of 110 antenatal patients who attended obstetric unit of Kasturba Medical College, Manipal. All patients were examined at or near term. The fetal weight was estimated within a week prior to the delivery. If the delivery did not occur within a week of the ultrasound examination, the estimations were repeated and these repeat estimations were taken into consideration. Clinical estimation of fetal weight was done for comparative analysis using Johnson's and Insler's formula in all these patients.

Ultrasonic measurements are made with linear array real time ultrasound equipped with a 3.5 MHz transducer. Ultrasound measurements of BPD, HC, AC, FL and TC were done. Only measurement of thigh circumference will be described as others have been standardized in obstetric ultrasound practice.

Measurement of thigh circumference

The whole length of femur from 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 that the thigh profile was as round as possible and the boundary of the thigh profile well defined. The thigh circumference was determined with elliptical approximation three times and then the average was taken as the final measurement.

The formulae for calculation of the estimated fetal weight were shown in the formula table below.

Formula Table for Calculation of Estimated birthweights

Methods	Parameters	Formulae
Johnson R.W (1957)	Symphysio-fundal height (SFH)	BW=(SFH- N) x 155 N=12 when station of fetal head is above the level of ischial spines (or) N=11 if presenting part is at or below the level of spines.
Insler and Bernsteins (1967)	SFH and Abdominal girth (AG)	BW (Birthweight) =SFH x AG
Hadlock et al (1985)	BPD, AC and FL	Log10 (BW) = -1.5213 + 0.003343 x AC x FL+ 0.001837 x BDD^2 + 0.0458 x AC + 0.158 x FL
Vintzileos et al (1987)	BP, AC, FL and TC	Log10 (BW) = 1.897 + 0.015 x AC + 0.057 x BPD + 0.054 x FL + 0.011 x TC

Within half an hour of delivery, neonates were weighed on weighing scale and actual weight of the neonate was compared with clinical and ultrasound estimated fetal weight. Thigh circumference of the neonate was measured at the middle of the thigh using measuring tape for comparison with ultrasound measurements.

STATISTICAL ANALYSIS

Data were analysed using Statistical Package for Social Sciences (SPSS version 7.5) and Microsoft Excel 2002. The above mentioned birth weight formulae were incorporated into an Excel worksheet and fetal weights were automatically calculated as soon as the respective parameters were entered. Calculation of mean, standard deviation, regression analysis and the other descriptive statistics (for example, percentile values for absolute error of difference) were done by SPSS software and chi square analysis for statistical significance was performed using Microsoft Excel. The differences were considered significant if p value was less than 0.05.

RESULTS AND ANALYSIS

Of 110 patients examined, 55% were primigravidae and 45% were multigravidae. Thirty nine neonates weighed less than 2500 grams (36%), 33 between 2501 to 3000 grams (30%), 30 between 3001 to 3500 grams (27%) and 8 weighed more than 3500 grams (7%).

Table I. Comparative analysis of birth weights in different weight groups.

Methods	**≤ 2500**	**2501-3000**	**3001-3500**	**>3500**	**Overall**
	n=39	**n=33**	**n=30**	**n=8**	**n=110**
Actual Birthweight	2253	2804	3303	3869	2822
Insler	2477	3007	3484	3896	3194
Johnson's method	2639	3257	3737	4072	3227
Hadlock	2600	3151	3684	4028	3013
Vintzileos	2183	2660	3184	3726	2711

Table I shows the actual birth weight compared with the predicted birth weight in different weight categories. Up to 3500 gms, Vintzileos proved better than all methods and this difference was statistically significant. However in weight group >3500 gms, Vintzileos was comparable to Insler, Johnson and Hadlock, but the sample size was small (eight patients only).

Table II. Mean of difference from actual birth weight in different weight categories.

Methods	**<2500gms**	**2501-3000gms**	**3001-3500gms**	**>3500gms**	χ^2	**P-value**
Insler	±356	±360	±394	±360	12.4	0.02
Johnson	±388	±456	±441	±371	11.6	0.003
Hadlock	±237	±223	±220	±373	6.4	0.04
Vintzileos	±101	±156	±136	±173	2.7	0.26

Table II shows the mean differences between the estimated birth weight and the actual birth weight in different weight categories. The method of Vintzileos produced the least difference from the actual birth weight compared to the other three methods. From chi square analysis, it was found that birth weight predicted by Vintzileos model was not significantly different from the actual birth weight ($\chi^2 = 2.7$, $p = 0.26$), where as there was significant difference in birth weight prediction in other three methods (Insler, $p = 0.002$, Johnson, $p = 0.003$, Hadlock, $p = 0.04$).

From **Table III**, it can be seen that percentile values for error are least with Vintzileos model.

It can be inferred from **Table IV**, that Vintzileos model is superior to all other models in its ability to predict the estimated birth weight nearest to the actual birth weight, especially in the underweight babies (<2,500 gm) at 95% predictability.

Table III: Percentile Values for Absolute Error of Difference.

Method	5th percentile	10th percentile	25th percentile	50th percentile	75th percentile	95th percentile
Insler	33	50	150	200	300	609
Johnson	58	100	250	373	518	972
Hadlock	52	74	187	321	528	915
Vintzileos	7	18	59	108	174	359

Table IV. Ability of each method to predict expected birth weight within 10% in different weight categories.

Method	**<2500 gms**	**2501-3000 gms**	**3001-3500 gms**	**>3500 gms**
Insler	26%	27%	50%	25%
Johnson	10%	30%	33%	63%
Hadlock	51%	70%	77%	75%
Vintzileos	95%	73%	96%	88%

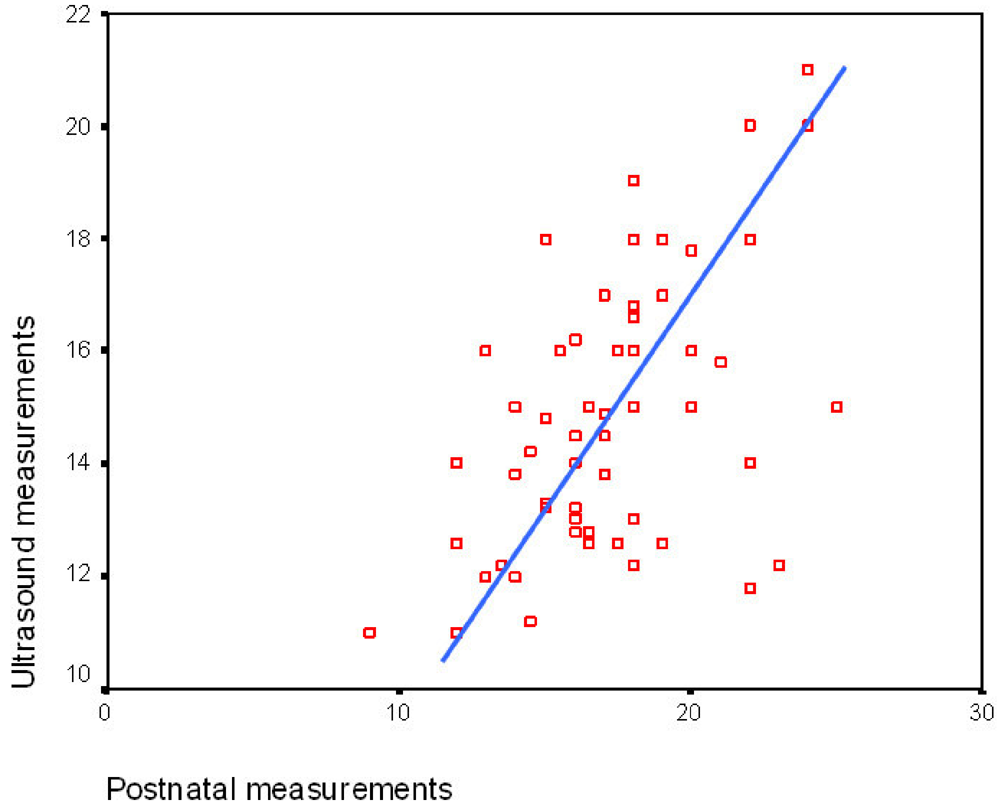
Table V: Results of Mc Nemar Chi-square tests in evaluating 2 methods to predict birth weight within 10% in different weight categories.

Birth weight up to 2500 grams (n=39)			
Method	**Chi-square**	**P value**	**Inference**
Vintzileos vs. Insler	15.2	<0.05	Vintzileos is better than Insler
Vintzileos vs. Johnson	32.9	<0.05	Vintzileos is better than Johnson
Vintzileos vs. Hadlock	25.1	<0.05	Vintzileos is better than Hadlock
Birth weight up to 2501-3000 grams (n=33)			
Vintzileos vs. Insler	0.06	<0.05	Vintzileos is better than Insler
Vintzileos vs. Johnson	9.4	<0.05	Vintzileos is better than Johnson
Vintzileos vs. Hadlock	9.3	<0.05	Vintzileos is better than Hadlock
Birth weight up to 3001 to 3500 grams (n=30)			
Vintzileos vs. Insler	15.2	<0.05	Vintzileos is better than Insler
Vintzileos vs. Johnson	32.9	<0.05	Vintzileos is better than Johnson
Vintzileos vs. Hadlock	25.1	<0.05	Vintzileos is better than Hadlock
Birth weight above 3500 grams (n=8)			
Vintzileos vs. Insler	0.01	>0.05	Vintzileos is comparable to Hadlock, Insler and Johnson formula. This may be due to small sample size in this group.
Vintzileos vs. Johnson	1.5	>0.05	
Vintzileos vs. Hadlock	1.4	>0.05	

Table V shows statistical analysis using Mc Nemar Chi-Square test for two independent variables. From this table, it can be seen that Vintzileos method incorporating thigh circumference provides a better model in predicting birth weight by ultrasound as compared to the other three methods.

There was a good correlation between ultrasound measurement and the actual postnatal measurements of thigh circumference **(Graph 1)** in the present study (r2=0.89, p<0.01).

The descriptive statistics for FL/TC ratio were also calculated. The mean ± SD and 95% confidence interval were found to be 0.458 ± 0.106 and 0.28 - 0.63 respectively. Thus based on this small study, we suggest that FL/TC ratio >0.63 may be taken as indicator of IUGR.



Graph 1. Relation between ultrasonically measured thigh circumference and postnatal thigh circumference.

DISCUSSION

The results of this study indicate that fetal thigh circumference measurements can add further to the accuracy of birth weight estimation in obstetric practice especially in babies of <2.5 kg with 95% predictability. 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 diameter measurements as it is less sensitive to changes in shape. Warda A et al (1986) conducted a comparative ultrasound and anatomical study to establish the anatomical location of the site proposed for making fetal thigh circumference measurements with ultrasound and opined that the correct plane lies at the junction of upper and middle third of fetal thigh. The difference of 4% between the ultrasound and the anatomical measurements was found in the same study. Measurement error was found to be less than 5% indicating the TC is comparable to BPD and AC as per evaluation of measurement errors by Deter RL et al (1982). The other growth curves of thigh circumference presented by Jeantry P et al (1985) showed slight differences as the profile was located at the mid level of the femur. Vintzileos et al (1987) measured the TC at the same plane used in our study but the TC was then calculated from diameter or measured directly using a map measurer.

Formulae incorporating thigh circumference measurements may prove most useful in predicting fetal weight when growth abnormalities are present. Fetal growth aberrations such as IUGR are associated with changes in the soft tissue mass which is decreased in these cases. Pediatric experiences have shown that the thigh circumference is one of the parameters that reflect soft tissue mass (Mattoo GM et al, 1991).

Fetal growth abnormalities are associated with alterations in thigh muscle mass and subcutaneous fat deposition around the periphery and these issued are not addressed in conventional ultrasound models. In order to explore potential use of limb measurements, Faver R et al (1995) conducted a prospective study on fetal weight estimation using TC as one of the parameters. They confirmed that use of thigh circumference not only enhanced the detection of small-for-dates fetuses, but also macrosomic fetuses. The current study do agree with the above study in estimation of fetal weight of <2.5 kg with 95% predictability. The same could not be said for macrosomic babies in this study. However, it should be noted that the number of babies >3.5 kg in this study was only 8, which was quite small for statistical analysis.

Recently imaging fetal limb volume by 3D ultrasound has proved that fetal thigh measurements facilitate accurate prediction of birth weight (Song TB et al, 2000, Lee W et al, 2001). Lee W et al (2001) used 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 centers 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 malpositions (Minako et al, 2000). Moreever, not many ultrasonographers 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.

The FL/TC ratio in this study showed 95% confidence interval of between 0.28 to 0.63. Thus, based on this small study, it appeared that an FL/TC ratio of >0.63 would suggest IUGR and can be taken as an indicator of this condition in-utero. However, a larger prospective study will be needed to validate the accuracy of the FL/TC ratio as well as the cut-off point to detect IUGR.

CONCLUSION

It can be concluded that, based on this small study on 110 babies, thigh circumference has a role to play in accurately measuring fetal weight when incorporated with other fetal parameters. When used as a ratio to femur length (FL/TC), there seems to be potential for its use in predicting IUGR.

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