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Critical Evaluation of Various Methods of Estimating Fetal Weight by Ultrasound

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OBJECTIVE - This prospective study was conducted to know which sonographic method of estimation of fetal weight reliably predicts the birth weight. **METHOD** - One hundred patients were scanned thoroughly within 48 hours of delivery. Seven different models of ultrasonic weight estimation were analysed critically. **RESULTS** - It was found that the method of Hadlock[1], predicted the birth weight more accurately than others. The average deviation from the actual birth weight (226gms) and the percentile values of absolute error of difference were least with this method and it predicted maximum number of 85% cases within + 10% of actual birth weight. Significant differences were observed between the predicted and actual birth weight in all other methods ($p<0.01$). **CONCLUSION** - Hadlock's[1] method is superior predictor of birth weight compared to other six and is a method of choice to estimate the birth weight in term pregnancies where the measurements of fetal head is inaccurate either because of engagement or moulding, as it incorporates only FL and AC measurements which are not affected by these changes.

Key words : prediction of birth weight, ultrasonography

Aims and Objectives

In the last two decades, various models have been designed by different investigators to predict fetal weight using ultrasound. The desired outcome is achieved by measuring different fetal anthropometrical parameters. These investigators have found that an approximate estimation of fetal weight may be made by measuring biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femurlength (FL).

Different models of ultrasound estimation of fetal weight have been proposed by Hadlock [1,2] Birnholz[3], Deter et al[4], Jordaan[5], Shepard[6] and Warsof et al[7] of which Hadlock[1,2] and Shepard[6] methods are most popular. However, these methods have not been evaluated in the Indian context. A study was undertaken to analyse the accuracy of these seven methods to predict birth weight.

Materials and Methods

This study was conducted at Dr. T.M.A. Pai Hospital, Udupi which is our peripheral unit, between January 2000 and June 2000. This hospital mainly caters to a low-risk obstetric population from low and mid socioeconomic groups in the surrounding villages. The high-risk patients like those who are having preterm labour, are usually referred to the main hospital and hence only term pregnancies were selected for this study.

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The patients studied were between the ages of 21 and 36 years, 43 were primigravidas and reminder 57 were multigravidas and none had more than four pregnancies. Most of the patients could be recruited to study because either they got admitted for safe confinement as they hailed from a distant village or because they were posted for elective cesarean section.

Patients were scanned within 48 hours of delivery using "TOSHIBA CAPASEE" (Toshiba Electronics, Japan) ultrasound scanner. A 3.5 Mhz abdominal transducer was used to obtain biparietal diameter (BPD), occipitofrontal diameter (OFD), anteroposterior and transverse abdominal diameters (AD1 and AD2) and femur length (FL) in centimeters.

Head circumference (HC) was obtained using the equation : $HC = p (BPD+OFD) / 2$

Abdominal circumference (AC) was calculated using the formula : $AC = p (AD+AD2) / 2$

Average abdominal diameter was calculated by using the equation : $AD = (AD1+AD2) / 2$

One of the methods (Birnholz[3]) needed corrected BPD value which was obtained by : Corrected BPD = $(BPD*OFD/1.264)^{0.5}$

Table I Shows formulas in different methods to arrive at estimated weight by ultrasound.

Within 15 minutes of delivery, neonates were weighed on an electronic scale (with accuracy of ± 5gms) and the actual weight of the neonate was compared with ultrasonically estimated fetal weight. The difference between the two was recorded as error in grams.

Table I : Formulas used in Different Methods

Models			Equations
Birnholz[3]	BW	=	(3.42928*BPD* AD2+41.218) / 1000
Deter et al[4]	Log10 (BW)	=	-2.014 +0.211*BPD+0.057* AC – 0.00403*BPD*AC
Hadlock et al[2]	Log10 (BW)	=	1.5213+0.003343*AC*FL+0.001837*BPD2+0.0458*AC+0.158*FL
Hadlock et al[1]	Log10 (BW)	=	-1.696+0.1938*FL+0.5281*AC-0.004*FL*AC
Jordaan[5]	Log10 (BW)	=	-1.683+0377*AC+0.095*BPD-0.0015*AC*BPD
Shepard et al[6]	Log10 (BW)	=	-1.7492+0.166*BPD+0.046* AC-0.002646*AC*BPD
Warsof et al[7]	Log10 (BW)	=	-1.599+0.144*BPD+0.032*AC-0.000111*BPD*AC

Statistical methods :

The primary objective of this study was to determine how accurately each of the methods predicted the actual observed birth weight and to compare them with each other. The accuracy of prediction was defined as the absolute difference between the predicted and observed weight. The data analysis was performed with the help of a personal computer using SSPS version 7.5 (Statistical Package for Social Sciences). As the distribution of absolute error was distinctly nongaussian, nonparametric test for paired data was performed using Wilcoxon's signed ranks method for paired data.

Table II shows that the mean birth weight in Hadlock[1] method was comparable to that of mean of actual observed birth weight.

Table II : Mean Birth Weight

Methods	Mean Birth Weight (gms)	Standard Deviation (gms)
Birnholz[3]	3064	440
Deter[4]	2738	390
Hadlock[2]	2767	383
Hadlock[1]	2834	387
Jordaan[5]	2760	366
Shepard[6]	2714	397
Warsof[7]	2580	383
Actual Weight	3874	499

Percentile values for absolute error of difference in different methods (in grams) are shown in Table III. It can be seen that the percentile values for error were least with Hadlock[1] model

The overall variation from actual birth weight in each model is given in Table IV (Absolute values are considered for analysis). It can be seen that the variation was least in Hadlock model.

Table IV : Deviation from Birth Weight

Methods	Deviation from Actual birth weight
Birnholz[3]	± 325 gms
Deter[4]	± 285 gms
Hadlock[2]	±260 gms
Hadlock[1]	±226 gms
Jordaan[5]	±280 gms
Shepard[6]	±295 gms
Warsof[7]	±386 gms

Accuracy of different methods to predict birth weight within ± 5% and ±10% of the actual birth weight is shown in Table V.

Table V : Accuracy of Methods

Methods	±5%	±10%
Birnholz[3]	30	55
Deter[4]	42	75
Hadlock[2]	45	78
Hadlock[1]	53	85
Jardaan[5]	46	74
Shepard[6]	41	73
Warsof[7]	28	53

Table III : Percentile Values for Absolute Error of Difference

Models	5th percentile	10th percentile	25th percentile	50th percentile	75 percentile	95th percentile
Birnholz[3]	32.3	61.5	120.8	237.8	438.6	558.4
Deter[4]	15.3	26.2	66.1	163.2	283.2	597.3
Hadlock[2]	19.6	30.5	81.8	153.5	270.9	537.9
Hadlock[1]	7.3	28.9	62.8	144.1	259.9	526.8
Jordaan[5]	11.2	40.7	71.5	157.8	286.1	578.8
Shepard[6]	12.2	23.9	70.5	176.1	282.7	628.8
Warsof[7]	19.4	51.8	123.9	276.7	406.9	761.9

It can be seen that Hadlock[1] method predicted the birth weight in 85% of cases within + 10% of actual birth weight.

Table VI shows the results of Wilcoxon's signed ranks test

Table VI : Significance of Difference Between Predicted and Actual Weight

Model	'Z' values	Two tailed Significance test (p value)	Significance
Birnholz[2]	-5.869[a]	<0.01	S
Deter[4]	4.700[b]	<0.01	S
Hadlock[1]	-3.878[a]	<0.01	S
Handlock	-1.840[a]	>0.01	NS
Jordaan	-3.772[a]	< 0.01	S
Shepard[6]	-5.380[a]	< 0.01	S
Warsof	-8.187[a]	< 0.01	S

[a] Based on negative ranks ; [b] Based on positive ranks.

It is evident from Table VI that the difference between the predicted fetal weight and the actual observed birth weight is highly significant except by the Hadlock[1] and all methods under estimate birth weight except that of Birnholz's[2].

Discussion

From this study it can be concluded that Hadlock's[1] method using FL and AC is more accurate in predicting the birth weight in term fetuses. This may be due to the fact that towards term, the head has the tendency to fix or engage resulting in error in measuring head size. The moulding of head toward the term may also contribute to this phenomenon.

In the present study, all methods except that of Birnholz[2] underestimated the fetal weight. Even though Hadlock[1] method using FL and AC slightly underestimated the fetal weight, it was close to the actual observed birth weight compared to other methods. It also could predict birth weight in maximum number of cases within +10% of actual birth weight.

The improved weight estimate obtained using the method of Hadlock[1] is based on the fact that FL is related linearly to crown heel length and according to Jordaan[5], crown heel length affects birth weight more significantly than the head size. Also it is easy to reproduce correct FL measurements, whereas head measurements may be affected by variation of the shape of the head and moulding. Difficulty is also experienced in obtaining valid measurements when the head is deeply engaged in the pelvis.

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