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Ultrasonic Foetal Weight Estimation at Term in Bangladeshi Women - A Comparative Study of Eight Formulae

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ABSTRACT

Background: Predicting foetal weight is of immense practical significance to the obstetricians to decide intensive perinatal care and planning mode of delivery. Several formulae based on ultrasound measurement of foetal biometry have been developed for foetal weight estimation. However, different investigators put forward different opinions regarding predictive accuracy of these formulae. This cross-sectional study was conducted in Dhaka Medical College Hospital to compare the accuracy of these formulae in predicting foetal birth weight in term pregnancy.

Methods: A total of 100 pregnant women who completed 37 weeks of gestation and were free from multiple pregnancies or medical diseases and whose foetuses did not exhibit any sign of IUGR or anomalies on ultrasound examination were included in the study.

Result: The result showed that the mean values of biparietal diameter (BPD), head circumference (HC), foetal length (FL) and abdominal circumference (AC) were 9.11± 0.32 cm 32.57 ± 1.75 cm, 7.20 ± 0.40 cm and 32.96±1.83 cm respectively. The formulae of Hadlock (AC), Warsof (FL), Hadlock (BPD, HC, AC, FL) and Hadlock (HC, AC, FL) underestimated foetal weight by 32.5%, 19.9%, 0.9% and 2.6% respectively, where as those of Shepard (BPD, AC), Warsof (BPD, AC), Woo (AC, FL) and Roberts (BPD, HC, AC, FL) overestimated foetal weight by 5.9%, 12.8%, 10.5% and 6.1% respectively. About 75% and 84% of the predicted weight by Hadlock (BPD, HC, AC, FL) were found to lie within 10% and 15% of the actual weight. Hadlock (HC, AC, FL) predicted 72% and 81% within 10% and 15% error respectively followed by Shepard (BPD, AC) (66% and 82% respectively) and Roberts (BPD, HC, AC, FL) (50% and 70% respectively). Woo (AC, FL), Warsof (BPD, AC), Warsof (FL) and Hadlock (AC) occupied 5th, 6th, 7th and 8th position respectively in estimating foetal weight within 10% and 15% of the actual weight. The correlation of estimated foetal weight with actual birth was highest (0.560) for Hadlock (HC, AC, FL) and that of lowest (0.190) for Warsof (BPD, AC).

Conclusion: The best prediction of foetal weight can be made by Hadlock (BPD, HC, AC, FL), while the predictions made by Hadlock (HC, AC, FL) and Shepard (BPD, AC) lie very close to it. However, the formula combining AC with FL could have practical implication where head measurements are frequently inaccurate.

Key words: Biparietal diameter (BPD), head circumference (HC), foetal length (FL), abdominal circumference (AC), prediction of foetal weight and actual birth weight.

ORIGINAL ARTICLE

Introduction

An accurate estimation of foetal weight is valuable information in planning the mode of delivery and management of labour. Several formulae based on ultrasound measurement of foetal biometry have been developed for foetal weight estimation. In the attempt to improve the accuracy of foetal weight prediction, various foetal anatomical measurements have been used either alone or in combination.

Formulae based on the abdominal circumference (AC) are thought to predict the foetal weight more accurately in preterm babies than in term foetus.[1] Shepard et al. have suggested that formulae based on biparietal diameter (BPD) & AC accurately predict foetal weight within 10% of actual weight.[2] The addition of femur length (FL) seems to improve the foetal weight prediction.[3] Formulae that combine AC, BPD & FL are reported to best prediction for foetal weight.[4] Thus, eight formulae have so far been developed to predict

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foetal weight and different investigators put forward different opinion regarding predictive accuracy of foetal weight. Even investigators are of the opinion that ethnic background affects foetal biometry and birth weight and this is attributed to genetic differences rather than nutritional or socioeconomic circumstances.[5] The formulae for estimating foetal birth weights are based on ultrasonographic foetal biometric measurements from mainly Caucasian populations. The performance of these formulae has not been extensively studied in Bangladeshi population. Identifying formulae that are able to accurately predict the foetal weight in Bangladeshi populations can be of great help to the caring obstetrician. The present study aimed to compare the accuracy of eight sonographic formulae for predicting foetal weight at term in Bangladeshi population.

The formulae for estimating foetal birth weights are based on ultrasonographic foetal biometric measurements from mainly Caucasian & other populations. The accuracy of these formulae has not been extensively studied in Bangladeshi population. The present study is intended to find out the appropriate formulae for predicting ultrasonic foetal weight at term pregnancy in Bangladeshi women.

Patients & Methods

The present cross-sectional comparative study conducted in the Departments Radiology & Imaging and Obstetrics & Gynaecology, Dhaka Medical College Hospital over a period of one year extending from January to December 2006. A total of 100 pregnant women admitted for deliveries at term, either being a candidate for normal delivery or caesarean section, were consecutively included in the study. Multiple pregnancy, confirmed or suspected IUGR, confirmed foetal abnormalities and associated medical diseases like heart disease and diabetes were excluded from the study. The following eight formulae were used to calculate foetal weight.

1. Hadlock (AC) - (Hadlock et al[6])
   $\mathrm{Ln\ EFW} = 2.695+0.253(AC) - 0.00275(AC)^2$
2. Warsof (FL) (Warsof et al[7])
   $\mathrm{Ln\ EFW} = 4.6914+0.151(FL)2 - 0.0119(FL)^2$
3. Shepard (BPD, AC) (Shepard et al[8])
   $\mathrm{Log_{10}\ EFW} = -1.7492+0.166(BPD)+0.046(AC)-0.002546(AC)(BPD).$

1. Warsof (BPD, AC) (Warsof et al[9])
   $\mathrm{Log_{10}\ EFW} = 1.599+0.144(BPD)+0.032(AC)-0.000111(BPD)^2 (AC).$
2. Woo (AC, FL) (Woo et al[10])
   $\mathrm{Log_{10}\ EFW} = 0.59+0.08(AC)+0.28(FL) - 0.00716(AC)(FL).$
3. Hadlock (BPD, HC, AC, FL) (Hadlock et al[11])
   $\mathrm{Log_{10}\ EFW} = 1.3596+0.0064(HC)+0.0424(AC)+0.174 (FL)+0.00061(BPD) (AC)-0.00386(AC) (FL).$
4. Hadlock(HC, AC, FL) (Hadlock et al11)
   $\mathrm{Log_{10}\ EFW} = 1.326\ 0.00326(AC) (FL)+0.0107 (HC)+0.0438 (AC)+0.158(FL).$
5. Roberts (BPD, HC, AC, FL) (Roberts et al[12])
   $\mathrm{Log_{10}\ EFW} = 1.6758+0.01707(AC)+0.042478 (BPD)\ 0.05216 (FL)+0.01604(HC).$

Having informed consent obtained from the selected participants, ultrasound measurements were taken using 3.5MHz convex transducer (Fukuda). The foetal head (HC) measurements were made in the axial plane at the level where the continuous midline echo was broken by the septum pellucidum cavum in the anterior third. Measurement of the BPD was made from the proximal echo of the foetal skull to the proximal edge of the deep border (outer-inner). The head circumference was measured around the perimeter using an electronic ellipse.[13] The AC was measured in the transverse axial view of foetal abdomen at the level of the liver, identifying the spine and descending aorta posteriorly. The umbilical vein in the anterior third and the stomach bubble in the same plane; measurements were taken around the perimeter.[14] The FL was measured in a view where the full femoral diaphysis was seen in a plane as close as possible to a right angle to the ultrasound beam; measurements were taken from one end of the diaphysis to the other, not including the distal femoral epiphysis.[15] The operational definitions of eight formulae, already mentioned, were used to calculate foetal weight. The actual foetal weight was measured using an appropriate weight machine within 24 hours of delivery. The differences between the ultrasonographically predicted foetal weight and the actual weight (simple error) were recorded as errors in grams. Percentage error was calculated using the following equation:

Percentage error = estimated weight-actual weight/ actual weight x 100.

Negative values of simple error and percentage error indicate that the foetal weight (FW) was underestimated and positive values indicate that it was overestimated. The absolute error was defined as the percentage error in absolute value (ignoring '+' and '-' signs). The accuracy of each formula in predicting foetal birth weight was determined by calculating the correlation between the predicted and actual birth weight, the mean absolute error and the percentage of birth weight that was predicted to within ± 10% and ±15% of the actual weight.

Data were analysed using computer software SPSS (Statistical Package for Social Sciences) version 11.5. The test statistics used to analyse the data were descriptive statistics, like frequency, estimation of percentage of error on either side of birth weight, percentage of absolute error within 10% and 15% of birth weight, mean predicted weight, mean birth weight, standard deviation (SD) from the mean and Spearman's correlation. The level of significance was 0.05 and $p < 0.05$ was considered significant.

Results

The mean age of the study subjects was 25.64 ± 4.44 years. The gravidity ranged from1-6 with median gravidity being 2. Majority (73%) of pregnant women at ultrasound was at 37 to 38 weeks of gestation, 25% 39-40 weeks, and 2% > 40 weeks of gestation. The mean biparietal diameter (BPD) was 9.11 ± 0.32 cm with lowest and highest BPDs being 7.09 and 9.9 cm respectively. The mean values of head circumference (HC), femur length (FL) and abdominal circumference (AC) were 32.57 ± 1.75, 7.20 ± 0.40 and 32.96 ± 1.83 cm respectively, while the lowest and highest values for the same biometries ranged from 28.9-39.2, 6.09-9.97 and 27.0-38.3 cm respectively (Table 1). The correlation between estimated foetal weight and birth weight show that the formulae

Table I. Foetal biometry by ultrasonogram (n=100).

Foetal biometry (cm)	Mean	SD Range
Biparietal diameter (BPD)	9.11 ± 0.32	7.90-9.90
Head circumference (HC)	32.57 ± 1.75	28.9-39.2
Femur length (FL)	7.20 ± 0.40	6.09-9.97
Abdominal circumference (AC)	32.96 ± 1.83	27.0-38.3

of Hadlock (AC), Warsof (FL), Hadlock (BPD, HC, AC, FL) and Hadlock (HC, AC, FL) tend to underestimate foetal weight, where as those of Shepard (BPD, AC), Warsof (BPD, AC), Woo (AC, FL) and Roberts (BPD, HC, AC, FL) tend to overestimate foetal weight. The correlation of estimated foetal weight with actual birth ranged from a minimum of 0.190 for Warsof (BPD, AC) to a maximum of 0.560 for Hadlock (HC, AC, FL). Predicted foetal weights with all but Warsof (BPD, AC) formulae were found to be significantly correlated with actual birth weight ($p < 0.01$) (Table 2).

Table II. Correlation between estimated foetal weight and actual birth weight

Formulae	Correlated variables: Estimated foetal weight (mean±SD)	Correlated variables: Birth weight (mean±SD)	Correlation coefficient (r)
Hadlock (AC)	2.08 ± 0.02		0.547**
Warsof (FL)	2.48 ± 0.07		0.359**
Shepard (BPD, AC)	3.27 ± 0.08		0.469**
Warsof (BPD, AC)	3.50 ± 0.50	3.13 ± 0.38	0.190
Woo (AC, FL)	3.44 ± 0.44		0.460**
Hadlock (BPD,HC,AC,FL)	3.09 ± 0.38		0.545**
Hadlock (HC, AC, FL)	3.03 ± 0.40		0.560**
Roberts (BPD,HC,AC,FL)	3.31 ± 0.51		0.535**

** Correlation is significant at 0.01 level

The mean weight of babies at birth was 3.13 kg. The predicted mean birth weights with the formulae of Hadlock (AC), Warsof (FL), Hadlock (BPD, HC, AC, FL) and Hadlock (HC, AC, FL) were lower than the mean birth weight with lowest predicted weight being 2.08 kg with Hadlock (AC), while those with the formulae of Shepard (BPD, AC), Warsof (BPD, AC), Woo (AC, FL) and Roberts (BPD, HC, AC, FL) were somewhat higher than the mean birth weight with highest predicted weight being 3.5 kg with Warsof (BPD, AC) (Fig.1). The formulae of Hadlock (AC), Warsof (FL), Hadlock (BPD, HC, AC, FL) and Hadlock (HC, AC, FL)

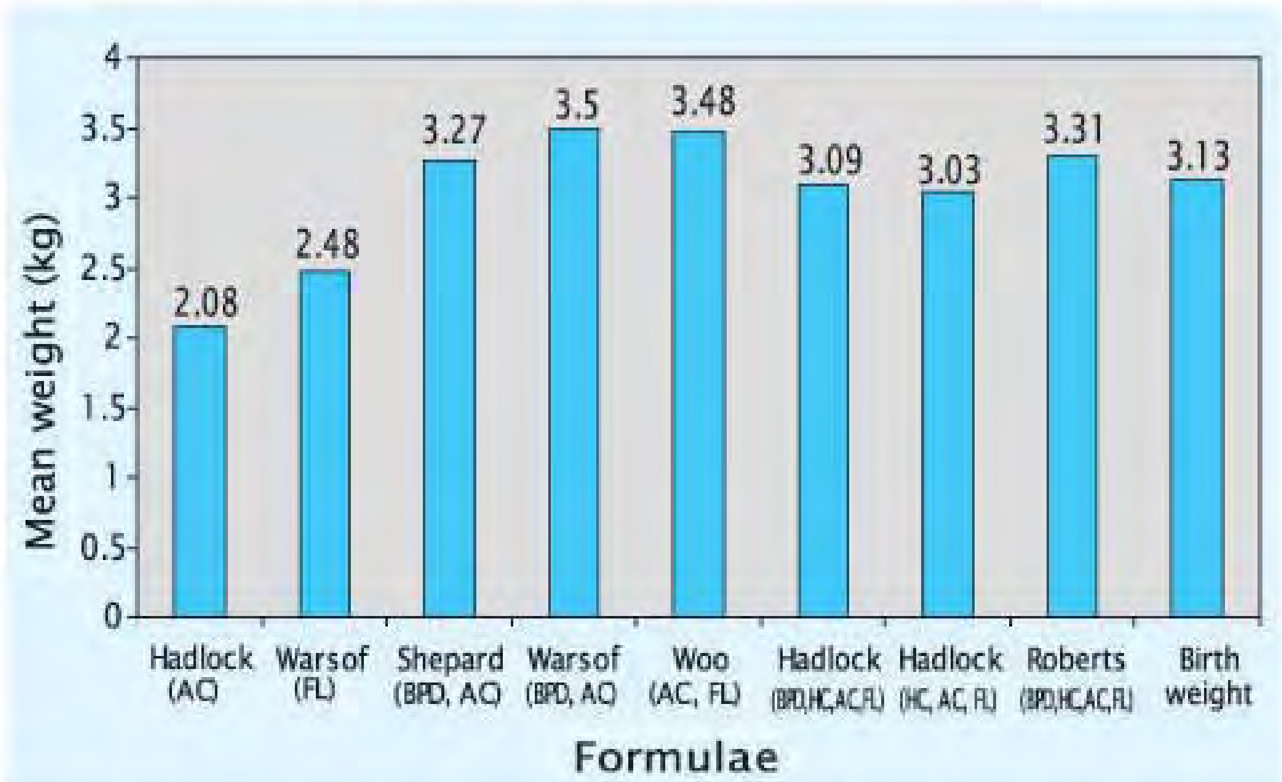

Fig. 1: Comparison of predicted foetal weights by different formulae (n=100).

ORIGINAL ARTICLE

underestimated foetal weight by 32.5%, 19.9%, 0.9% and 2.6% respectively, where as those of Shepard (BPD, AC), Warsof (BPD, AC), Woo (AC, FL) and Roberts (BPD, HC, AC, FL) overestimated foetal weight by 5.9%, 12.8%, 10.5% and 6.1% respectively (Fig. 2).

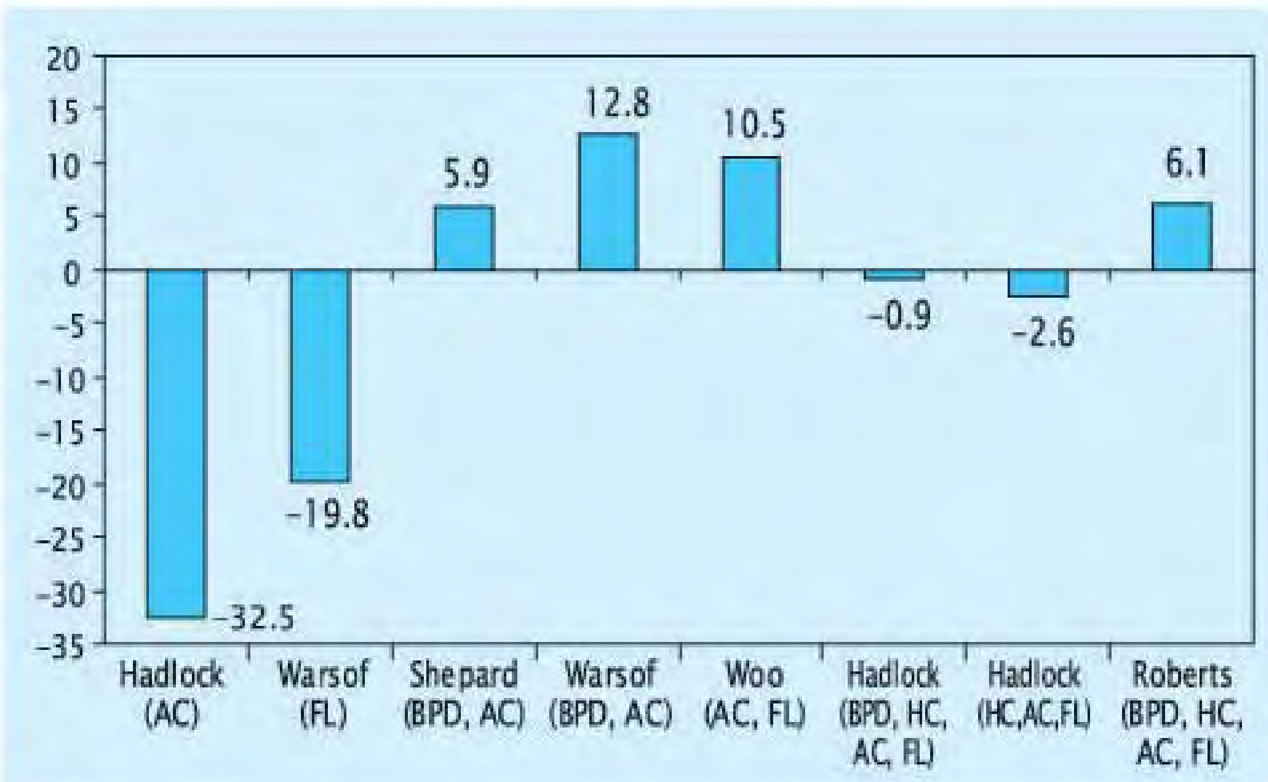

Fig. 2: Percentage of under and over estimation (n=100)

The accuracy of the formulae in predicting foetal weight within 10% and 15% of the actual birth weight is seen in fig. 3. About 75% and 84% of the predicted weight by Hadlock (BPD, HC, AC, FL) were found to lie within 10% and 15% of the actual weight. Hadlock (HC, AC, FL) predicted 72% and 81% within 10% and 15% error respectively followed by Shepard (BPD, AC) (66% and 82% respectively) and Roberts (BPD, HC, AC, FL) (50% and 70% respectively). Woo (AC, FL), Warsof (BPD, AC), Warsof (FL) and Hadlock (AC) occupied 5th, 6th, 7th and 8th position respectively in estimating foetal weight within 10-15% of the actual weight.

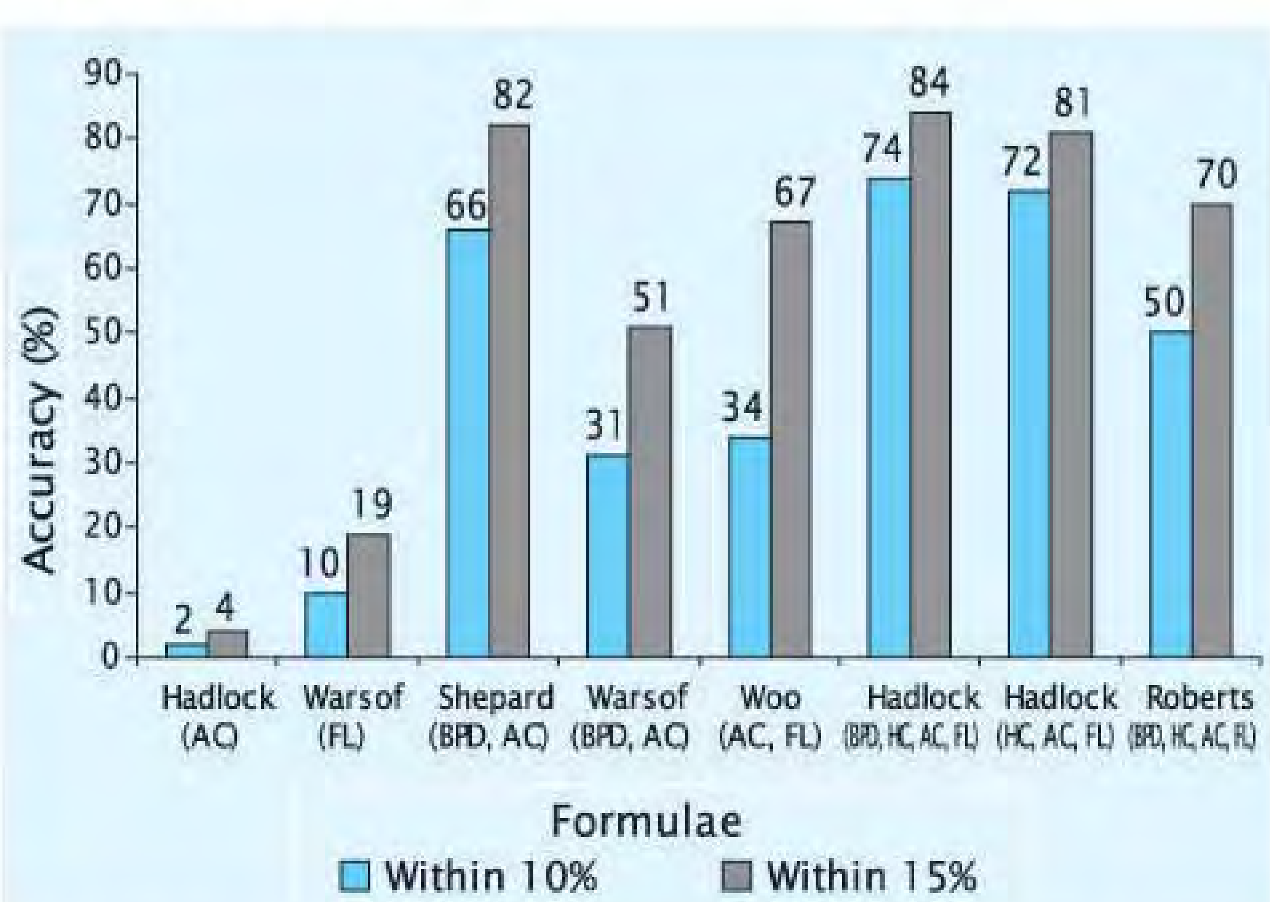

Fig. 3: Accuracy of formulae used to predict foetal weight (n=100).

Discussion

Since the introduction of ultrasonogram in the field of obstetrics in 1950, a major breakthrough has taken place in determining foetal age, weight and anomalies. However, controversy surrounding the estimation of foetal weight, using ultrasonogrphic measurements of foetal biometry is no less and as many as eight formulae so far have been developed to predict the foetal weight. The issue becomes more debatable, for the formulae are based on measurements mainly from Caucasian population. The implication of these formulae in wider population encompassing various ethnic groups has not been extensively tested. In an attempt to fulfill a part this gap the present study was conducted in Bangladeshi population.

In the present study the mean values of BPD, HC, FL and AC were 9.11 ± 0.32 cm 32.57 ± 1.75 cm, 7.20 ± 0.40 cm and 32.96 ± 1.83 cm respectively. The present study showed that the formulae of Hadlock (AC), Warsof (FL), Hadlock (BPD, HC, AC, FL) and Hadlock (HC, AC, FL) tend to underestimate foetal weight, where as those of Shepard (BPD, AC), Warsof (BPD, AC), Woo (AC, FL) and Roberts (BPD, HC, AC, FL) tend to overestimate foetal weight. The correlation of estimated foetal weight with actual birth was highest (0.560) with the formula of Hadlock (HC, AC, FL) and that of lowest (0.190) with the formula of Warsof (BPD, AC). The present study reveals that the formulae that use single foetal biometric variable like Hadlock (AC) or Warsof (FL) correlate poorly with actual foetal weight with less chance of predicted weight to lie within 10-15% error bearing consistency with findings of Hisham et al.[16] However, this finding contradicts with another study that reported that foetal weight predictions based extensively on the foetal AC is as accurate as those based multiple foetal biometric measurements.[17] Combining FL with AC together improves the prediction (34% of the predicted weights were within 10% error) by many-fold compared to when they are used alone (2% and 10% of the predicted weights with AC and FL respectively fell within 10% of the actual weight). Nevertheless, the formula is still inferior to that combining AC with BPD as in Shepard's formula which ensures 66% and 82% of predicted weight to lie within 10% and 15% error respectively suggesting that combining AC with

BPD measurements rather than FL helps achieving a high level of predictive accuracy. Shepard and her associates[2] also have confirmed the accuracy of combined BPD and AC for the estimation of foetal weight. It would make sense that the best estimates of foetal weight would involve measurements of both the head and the trunk as the majority of the body mass of the fetuses is occupied in these two areas. However, formula combining AC with FL can be of practical significance in situations where head measurements are frequently inaccurate when the patient is in labour with head lodged deeply into the pelvis or when the foetal head is in persistent occiput posterior or anterior presentations. Addition of head circumference (HC) to AC and FL as in Hadlock (HC, AC, FL) expedites the predictive accuracy to 72% and 81% within 10% and 15% error respectively. No appreciable change in prediction was, however, noted as BPD was further added (74% and 84% of the predicted weights were within 10% and 15% error) to this model.

The combination of multiple foetal measurements does not necessarily increase the accuracy in predicting foetal weight. The Shepard's (BPD, AC) formula involved only two foetal measurements and had significantly higher correlation and less mean absolute error (5.9%) from actual birth weight than that of Roberts (BPD, HC, AC, FL) (6.1%) and was not widely different from that of Hadlock (BPD, HC, AC, FL). Shepard[2] and her associates in 1982 in an attempt to compare their own model (Shepard BPD, AC) with that of Warsof's model (Warsof BPD, AC), generated from a different equation, found most estimates of both the formulae to be within 10% of actual weight. However, there was significant underestimation with Warsof's model. Shepard provides a better balance between the distribution of overestimation and underestimation. The present study well conforms with Shepard et al's study.[2] Although our sample did not involve multiethnic groups, Hisham's study suggest that Shepard (BPD, AC) performed well in the multiethnic population. Comparison of eight formulae in our study sample revealed Hadlock (BPD, HC, AC, FL) as the best formula for prediction of foetal weight in term pregnancy, while Hadlock (HC, AC, FL) and Shepard (BPD, AC) lie nearer to it. However, in some practical situation where head measurements are frequently inaccurate or not feasible at all due to foetal position, the formula combining AC with FL can be of practical significance. However, like all scientific studies the present study was not without limitation. The mean interval between ultrasound examination and delivery was 1.77 ± 1.17 weeks, while Hisham's study had an average interval of 1.2 ± 1.5 days. This might have affected the predictions, particularly underestimations made by different formulae.

The study concludes that the best formula for prediction of foetal weight in term pregnancy is Hadlock (BPD, HC, AC, FL), while the predictions made by Hadlock (HC, AC, FL) and Shepard (BPD, AC) lie in close proximity to it. These formulae might be of immense practical significance to our caring obstetrician to decide intensive perinatal care and planning mode of delivery.

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ORIGINAL ARTICLE

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ORIGINAL ARTICLE