Comparison of three clinical and three ultrasonic equations in predicting fetal birth weight

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ABSTRACT

Background: Antenatal assessment of fetal weight is important part in the management decisions during labour, thereby improving perinatal outcome. There are a large number of clinical methods and ultrasonic formulae for predicting fetal birth weight (EBW) with varying degrees of accuracy. This study was an attempt to compare the accuracy of three clinical and three ultrasonic methods in Indian population. The method with highest accuracy can be used in high and low resource setting in a country like ours with diverse resource settings.

Methods: This was a prospective non randomized cohort study done on 100 antenatal patients in PGIMER, Dr. RML Hospital; New Delhi from Nov 2011 to Jan 2013 EBW (Expected Birth Weight) was calculated applying the 6 formulae three clinical and three ultrasonic and statistical analysis done after delivery comparing with ABW (Actual Birth Weight).

Results: Accuracy in all ABW within 10% of ABW was 94 % with Johnson's method, 92 %with Dares method and 62 % with obstetrical equation. It was 100% with Hadlock 2 equation, 96% with Shepherd's and 86% with Warsoff equation Sensitivity for IUGR i.e. wt <2.5 kg was low in clinical methods, highest was only 46.2% with Johnsons. In ultrasonic methods all the three equations had 100% sensitivity making ultrasound the preferred modality in diagnosing macrosomia.

Conclusions: The major finding of this study is that clinical estimation of fetal weight is as accurate as ultrasonographic method of estimation within normal range of birth weight Ultrasonographic methods was statistically more accurate with smaller mean errors and more within 10% of actual birth weight. Johnson formula gave most accuracy in clinical methods Ultrasound should be used to confirm clinical methods if IUGR or Macrosomia is suspected. No single method should be used if EBW is a part of decision but two or more methods should be combined.

Keywords: Expected fetal birth weight, Actual birth weight, Johnsons formulae, Dare formulae, Obstetrical equation, Hadlock equation, Warsoff equation, Shepard equation

INTRODUCTION

An accurate determination of fetal weight prior to delivery has a significant bearing on the management decisions during labor thereby improving perinatal outcome injuries in mother. Estimated fetal weight is required for management decisions in high risk pregnancies as in intrauterine growth retardation (IUGR), diabetic pregnancy, and vaginal birth after caesarean section and in borderline CPD. Antenatal assessment of fetal birth weight before delivery is required in planning the management, optimal route of delivery and the level of hospital where the delivery should be conducted. In large for date fetus, the potential
complications associated with delivery include birth canal and pelvic floor injuries, postpartum hemorrhage, shoulder dystocia, brachial plexus injury and birth asphyxia.

There are a large number of clinical methods and ultrasonic formulae available in literature for predicting fetal birth weight with varying degrees of accuracy. Many studies are available in literature comparing clinical methods and ultrasonic methods among themselves and with one another. This study was an attempt to compare the accuracy of three clinical and three ultrasonic methods in Indian population. In a country like ours with diverse resource settings, the method with highest accuracy can be used depending on the available resource.

METHODS

This was a prospective non randomized cohort study done on 100 antenatal patients selected from labor room of a central government hospital, PGIMER, Dr RML hospital, New Delhi from Nov 2011 to Jan 2013, within a week of delivery.

Inclusion criteria

1. Confirmed dates
2. >34 week pregnancy
3. Cephalic presentation

Exclusion criteria

1. ruptured membranes
2. twin pregnancy
3. associated fibroid or ovarian tumor
4. Marked obesity BMI >40 kg/m
5. IUD

EBW (expected birth weight) was calculated applying the 6 formulae, three clinical and three ultrasonic. If delivery did not occur in one week they were measured again.

The present study was approved by the institutional ethics and research review board. All the selected patients were explained the purpose of this study and their consent was taken for the same. The accuracy of EBW by the six methods was compared with the ABW (actual birth weight) which was recorded after delivery.

Clinical estimation of fetal weight (EBW)

After emptying the bladder, the patient was placed in dorsal position and dextro-rotation of gravid uterus was corrected. With the help of a flexible non stretchable measuring tape symphysio-fundal height measurement in cm from the upper border of the symphysis pubis up to the fundus was taken, with reverse side up to avoid bias. Abdominal girth was measured in cm with the same measuring tape at the level of the umbilicus. PV examination was done to fine the station of head and to rule out ruptured membranes. Weight was calculated by these three formulas.

Johnson’s formula

Weight in grams = [SFH (symphysio-fundal height in cm) – x] × 155.

X=13, when presenting part is not engaged
X=12, when presenting part is at 0 station
X=11, when presenting part is at +1 station

Dare’s formula

Weight in grams = [symphysio-fundal height (cm) × abdominal girth (cm)]

Obstetrics equation

Five Feto - maternal characteristics were used.
1. Gestational age at delivery
2. Parity
3. Maternal height
4. Maternal weight at 26 weeks
5. Maternal weight gain rate/day. Fetal sex was not seen according to PNDT act.

Birth weight (grams) = [gestational age(d) × (9.36+0.000237×maternal height(cm) × maternal weight at 26 weeks(kg)) + 4.81×maternal weight gain rate (kg/d) × parity + 1].

Ultrasonographic estimation of fetal weight

The sonographic examination was performed with a 2-D Toshiba nemio X G ultrasound machine consisting of a trans abdominal convex array transducer with a frequency of 3.5 MHz. The information obtained included fetal dimensions particularly: BPD, FL and AC were measured according to standard techniques.

Hadlock’s formula 2 (already incorporated in ultrasound machine)

Log EBW = 1.335 – 0.0034(AC×FL) + 0.0316(BPD) + 0.0457 (AC) + 0.1623 (FL).

Calculation of fetal weight by the other two ultrasonographic formulae was done manually as they were not programmed in the ultrasound machine.

Shepard’s formula

Log EBW = [-1.7492 + 0.166(BPD) + 0.046(AC) - 2.646(AC × BPD) / 1000]
**Warsof2 formula**

Log EBW = [-1.599 + 0.144(BPD) + 0.032(AC) - 0.111(BPD²×AC) / 1000]

The EBW was taken by all the methods within a week of delivery. If the delivery did not occur within a week of estimation of the fetal weight by various formulae, then the estimation was repeated and these fresh values were taken in to consideration.

After delivery, ABW (Actual Birth weight) was recorded immediately by using TANITA 1583, digital weighing machine and EBW by various equations and ABW were compared.

**Statistical analysis**

Statistical analysis of the above results was calculated using the SPSS program for Windows version 17.0. EBW was calculated by 6 methods and compared with ABW. Accuracy was measured by three methods:

1. Absolute error
2. Absolute percentage error
3. Accuracy as within 10% of ABW. ABW was divided into four groups for statistical analysis: <2.5000 gms, 500-3,000 gms, 3,000-3,500 gms and more than 3,500 gms. The mean error represents the sum of positive (overestimation) and negative (underestimation) from actual birth weight.

Absolute error = EFW-ABW, absolute percentage error is calculated as EBW-ABW/ABWX100 and the ratio by percentage of estimate within 10% of actual birth weight. The difference in proportion of estimates within 10% of actual birth weight was assessed by the chi-square test with p <0.05 considered statistically significant.

**RESULTS**

**Table 1: Distribution of actual birth weight among 4 groups.**

<table>
<thead>
<tr>
<th>Actual BW</th>
<th>Frequency in study population%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2500 gm</td>
<td>13%</td>
</tr>
<tr>
<td>2501 – 3000 gm</td>
<td>47%</td>
</tr>
<tr>
<td>3001 - 3500 gm</td>
<td>37%</td>
</tr>
<tr>
<td>&gt;3500 gm</td>
<td>3%</td>
</tr>
</tbody>
</table>

The maternal age distribution was in the range of 21 – 38 years. Mean age being 28.2 ± 3.4 years. The average gestational age at delivery (AGA) was 264.80 days (37 weeks + 6 days) the range of 240 – 284 day Mean actual birth weight was 2912.73 gm, range 1560 – 3800gms.

For statistical analysis actual birth weight of fetus was divided in to four groups <2,500 gms, 2,500-3,000gms, 3,000-3,500gms and >3,500 gms. Maximum distribution of cases was in group 2501-3000 gm (47%) (Table 1). Statistical analysis was done between actual birth weight and estimated birth weight.

<table>
<thead>
<tr>
<th>S.no</th>
<th>Clinical Methods</th>
<th>Under Estimated</th>
<th>Over Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Johnson’s</td>
<td>32%</td>
<td>68%</td>
</tr>
<tr>
<td>2</td>
<td>Dare’s</td>
<td>16%</td>
<td>84%</td>
</tr>
<tr>
<td>3</td>
<td>Obstetrics equation</td>
<td>18%</td>
<td>82%</td>
</tr>
</tbody>
</table>

**Table 2: Number of cases over and underestimated by various methods.**

In our study accuracy in all ABW within 10% of ABW was 94% with Johnson's method, 92% with Dares method and 62% with obstetrical equation. However among ultrasonic methods Hadlocks equation (94%) increasing its sensitivity for diagnosing IUGR and in ultrasonic methods, Warsoff's equation 99% chance to underestimate fetal weight.

Dares overestimated in maximum number (84%) and in ultrasonic methods Hadlocks equation (94%) increasing their sensitivity to detect macrodromia (Table 2).

Among the clinical formulae Johnson’s formula was showing least mean differences (45.60 gms) from ABW. Among the three ultrasonographic equations Hadlock’s formula was showing least mean differences from actual birth weight (26.88 gms). Obstetric equation & Warsof formula was showing mean differences of 210.80gm & 202.14 gm (Figure 1). All clinical formulae were showing more mean absolute % error in group <2500 gm. However Obstetric equation was showing maximum mean absolute % error in each group than other, with zero specificity for IUGR. In all ultrasonographic formulae Hadlock’s was showing least mean absolute % error in each group except in >3500 gm. Warsof formula was showing least absolute error than Hadlock’s in group >3500 gm (Figure 2 & 3). All USG formulae were more correlated to ABW as compare to clinical formulae.

Sensitivity for IUGR i.e. wt <2.5 kg was low in clinical methods; highest was only 46.2% with Johnsons method and 0 for obstetrical equation. However among ultrasonic methods highest sensitivity was with warsoff (100%) and lowest was for Hadlocks method (84.6%). Clearly ultrasonic methods were better in predicting IUGR.
Specificity was 100 % for all three clinical methods. In ultrasonic methods, specificity was 100% for Hadlock's method (Figure 4).

Table 3: Various ultrasonic equations used to predict fetal weight.

<table>
<thead>
<tr>
<th>No.</th>
<th>Author</th>
<th>Year</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Campbell</td>
<td>1975</td>
<td>LnBw = 4.564 + 0.0282 (AC) − 0.00331 (AC)^2</td>
</tr>
<tr>
<td>2</td>
<td>Warsof</td>
<td>1977</td>
<td>Log10Bw = −1.599 + 0.32(AC) − 0.000111(BPD)^2(AC)</td>
</tr>
<tr>
<td>3</td>
<td>Shepard</td>
<td>1982</td>
<td>Log10Bw = −1.7492 + 0.166(BPD) + 0.046 = 0.002546 (AC) (BPD)</td>
</tr>
<tr>
<td>4</td>
<td>Hadlock I-AC,FL</td>
<td>1985</td>
<td>Log10 BW = 1.304 + (0.05281 X AC) + (0.1938 XFL) - (0.004 xAC x FL)</td>
</tr>
<tr>
<td>5</td>
<td>Hadlock II-BPD,AC,FL</td>
<td>1985</td>
<td>Log10 BW = 1.335 - (0.0034 X AC X FL) + (0.0316 BPD) + (0.04X7 ) (AC) + (0.1623 X FL)</td>
</tr>
<tr>
<td>6</td>
<td>Hadlock III-HC,AC,FL,XHC</td>
<td>1985</td>
<td>Log10 BW = 7.326 - (0.00326 X AC X FL) + (0.0107 + (0.0438 XAC) + (0.148 XFL)</td>
</tr>
<tr>
<td>7</td>
<td>Hadlock IV-BPD,HC,AC,FL</td>
<td>1985</td>
<td>Log10 BW=0.3596+(0.00061 XBPDXAC) + (0.042XAC) + (0.174XFL) + (0.0064XHC) - (0.00386XACX</td>
</tr>
<tr>
<td>8</td>
<td>Nzeh 1</td>
<td>1992</td>
<td>Log10Bw = 0.470 + 0.488 Log BPD + 0.554 Log10 FL + 1.377</td>
</tr>
<tr>
<td>9</td>
<td>Nzeh 2</td>
<td>1992</td>
<td>Log10Bw = 0.326 + 0.0045(SDI) + 0.383Log10BPD + 0.614 Log10FL +</td>
</tr>
<tr>
<td>10</td>
<td>Combs</td>
<td>1993</td>
<td>Bw = 0.23718(AC)^2(FL) + 0.03312(HC)^3</td>
</tr>
</tbody>
</table>

For macrosomia, sensitivity was 100 % for Dares method and in ultrasonic methods all the three equations had 100 % sensitivity making ultrasound the preferred modality in diagnosing macrosomia. Among clinical methods specificity for macrosomia was highest for Johnson’s methods 98.6 % and was above 95 % for all three ultrasonic formulae (Figure 5).

All clinical formulae was showing more absolute maximum error in group <2500 gm than ultrasonic methods. Obstetric equation was showing more maximum absolute error in each group (Figure 6).
maximum error than Dare’s formula. All ultrasonographic formulae were showing absolute maximum error in group 2501 – 3000 gm, which had the maximum distribution in study group. Using Hadlock’s formula, the maximum error in various fetal weight groups was most marked in <2500 gms.

There was significant co relation between SFH (symphosio-fundal height) and ABW, p<0.005 and r=0.879.

DISCUSSION

The importance of fetal birth weight estimation cannot be over emphasized as both low birth weight and excessive fetal weight at delivery are associated with an increased risk of maternal and neonatal complications during labor and puerperium. It was in 1954 that Johnson used SFH in predicting EFW. 1 In 1990 Dare included his method of combining abdominal girth and SFH. 2 Dawn used his modification by measuring skin fold thickness by calipers and used the formula weight (grams) = longitudinal diameter of the uterus x transverse diameter of the uterus x 1.44/2. If Double abdominal wall thickness was more than 3 cm, the excess was deducted from fundal height in cms A obstetrical equation was formulated by Shittu et al in 2007 and it was used in our study using multiple maternal parameters like maternal height, weight, and also rate of weight gain. It also included prenatal fetal sex which was excluded from our study (value given as 0). 3

Various equations have been used in ultrasound in the last three decades to estimate fetal birth weight. More than 30 equations are available in literature namely Hadlock 1-4, Shephard, Warsoff, Cambell, woo 1; woo 2 with varying accuracy (Table 3). Our study showed a clear role of clinical methods in estimating fetal weight at par with ultrasonic equations. In estimating weight <2500 gm & >3500 gm there is a role of ultrasound as additional tool Sensitivity and Specificity of ultrasonography formulae were more in <2500 gm and >3500 gm as compared to clinical method. All the three USG formulas had 100% sensitivity in predicting fetal weight more than 3.5 Kg. Among clinical methods in our study, Dares formula was 100% sensitive in predicting weight >3.5 Kg Kacem et al used MRI to predict EBW and found it more accurate then USG however it cannot be routinely used. 5

In our study we found Johnson equation giving a fair degree of accuracy compared to ultrasonic methods which had lower error at extremes of fetal weight. Obstetrical equation did not give good accuracy; however Shittu et al found it quite accurate in a study conducted in Nigeria. 6 Among ultrasonic equations Hadlock 2 gave good accuracy compared to other two ultrasonic equations. Literature is flooded with varying comparisons of clinical and ultrasonic. Most find comparable accuracy among clinical and ultrasonic methods.

Since Chauhan et al first published their study in 1992, several studies have confirmed that maternal estimates are as accurate as ultrasound estimates. 6 The studies of Hendrix et al and Raman et al showed that clinical estimation was more accurate than sonographic methods. Watson et all found no difference even at extremes of weight at term. 7 In another study by Chauhan et al in 1998 they found similar accuracy between clinical and
ultrasonic methods except in birth weight <2.500 gms.9
The study by Bhandari et al in Karnataka India and
Regina et al in 2005 in Brazil found similar accuracy in
the clinical and ultrasonic estimates Titapani in 1999 and
Mehdizadeh in 2000, in an Iranian population found
similar accuracy between clinical and ultrasonic
methods.12,16,18

Dudley used eleven ultrasonic prediction models and
concluded that there was no preferred method and
magnitude of errors were a major obstacle to confident
use in clinical practice.20 The study by Burd in 2009 used
fourteen different formulae in ultrasound for predicting
fetal weight and concluded wide variation in sensitivity
and specificity with no formula showing any superiority
over rest compared with clinical methods no advantage
was seen in ultrasound in extremes of fetal weight by
Hargreaves in a study published in 2011.22,23 Though not
validated recent studies done using 3,4 D USG measuring
foetal thigh measurements are showing significant
accuracy in macrosomic baby MRI is another costly
alternative which cannot be freely used routinely.24

Among the measures of accuracy used in our study
simple error was not a good predictor of accuracy and
was misleading as because it is a sum of over and
underestimates. In contrast absolute error and percentage
error and weight within 10% are better indicator of
accuracy as they represent variability regardless of
direction. There were few limitations in our study. The
drawback was that it tested hadlock formula which was
developed in 1985. Although some authors have
advocated the use of other equations, a recent systematic
review reported that the accuracy of Hadlock’s formula
did not differ significantly from other models.22

Another big drawback of our study was that it did not have
macrosomic babies in large number only three had
ABW >3.500 gms In our study we took macrosomia as
>3.5 kg as we did not get any newborn weighing more
than 4 kg in our study group. It was a general population
based study and more macrosomic babies are needed to
draw any conclusion from this study assessment in large
birth weight and also the extreme low birth weight.
In clinical methods the confounders were maternal
obesity and hydramnios.

The reason why ultrasound has its limitations in 2-D
because it may be noted that only spatial measurements
are made in ultrasound whereas fetal mass is a function
of fetal volume and density and density of fetus at term is
not constant. Routine 2 D USG has its limitations in
measuring volume. Also 15% of fetal birth weight at term
is adipose tissue which is increased in macrosomic babies
of diabetic mothers.

The positive point in our study was that it aimed to
compare two modalities available in two different
settings namely low cost easy estimation which could be
done by residents in low resource settings and at the same
time compared it with available ultrasound modality in

high resource setting. The drawback was that it tested a
hadlock 2 formula which was developed in 1985 and
many new equations have come up which need to be
tested in specific population.

CONCLUSIONS

The major finding of this study is that clinical estimation
of fetal weight is nearly as accurate as ultrasonographic
method of estimation within normal range of birth
weight. An ultrasonographic method was statistically
more accurate with smaller mean errors and more within
10% of actual birth weight. Johnson formula gave most
accuracy in clinical methods Hadlock 2 also proved to be
more accurate in ultrasonic equations.

It is recommended that symphysial fundal height be
routinely incorporated in antenatal care and utilized at
term to measure EBW by Johnson’s method. Ultrasound
should be used to confirm clinical methods if IUGR or
Macrosomia is suspected. No single method should be
used if EBW is a part of decision but two or more
methods should be combined. The equation fed into
ultrasonic machine should also be known. More studies
using the newer methods like thigh measurements using
3-D ultrasound need to be done specially for extremes of
fetal weight.

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REFERENCES

1. Johnson RW, Toshach CE. Estimation of fetal
weight using longitudinal mensuration. Am J Obstet
2. Dare FO, Ademowore AS, Ifaturoti OO. The value
of symphysio-fundal height/abdominal girth
measurements in predicting fetal weight. Int J
3. Shittu AS, Kutti O, Orji EO. Clinical versus
sonographic estimation of fetal weight in south west
4. Hadlock FP, Harrist RB, Sharman RS. Estimation
of fetal weight with the use of head, body, and femur
measurements—a prospective study. Am J Obstet
estimation: comparison of two-dimensional US and