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Original Research Article

Comparison of various method of fetal birth weight estimation in term pregnancy

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ABSTRACT

Background: Knowledge of fetal weight in utero is vital for the obstetrician in deciding whether or not to deliver the fetus as well as in fixing the mode of delivery. Both low birth weight and excessive fetal weight at delivery are associated with increased risk of newborn complications during labor and the puerperium. Various clinical formulae like Johnson's formula and Dare's formula and USG are in use for fetal weight estimation. The aim of this study was to assess the fetal weight in term pregnancies by various methods- Dare's formula, Johnson's formula and Hadlock's formula using ultrasound, and to compare the methods after knowing the actual weight of the baby after birth.
Methods: It is a prospective observational study of 227 women at term pregnancy at GMERS medical college and Hospital, Sola, Ahmedabad from April 2014 to April 2016. The formulas used in this study are: Johnson's formula, Dare's formula and Hadlock-4 formula using ultrasound.
Results: Results vary in terms of accuracy with various methods employed for estimating the fetal weight. This study showed that Hadlock-4 was the best indicator among all other methods assessed followed by Dare's formula.
Conclusions: Whenever the Facility is available, Ultrasound is the best method for birth weight assessment. Dare's formula is an inexpensive method for screening for fetal growth restriction. It continues to be used in many countries on large scale because of its low cost, ease of use, and need for little training as the setup for ultrasonographic evaluation is not readily available in rural setups.

Keywords: Dare's formula, Fetal birth weight, Hadlock-4 formula, Johnson's formula

INTRODUCTION

Accurate prenatal estimation of fetal weight in late pregnancy and labour is extremely useful in the management of labour and is an important indicator of pregnancy outcome.

It permits obstetricians to make decisions about instrumental vaginal delivery, trial of labour after caesarean delivery and elective caesarean section for patients suspected of having a macrosomic fetus.[1-5] Both low birth weight and excessive birth weight at delivery are associated with increased risk of newborn complications during labour and puerperium.[6]

Different methods of estimating fetal weight have been used and broadly they are classified as:

Clinical methods

Extensively used, convenient and virtually costless. Various clinical formulas like Johnson's formula, Dawn's formula and Dare's formula are used for fetal weight estimation.

Ultrasonography

Several formulae have been developed for estimating fetal weight by ultrasound.[4,7-10] These formulae involve a variety of sonographically obtained biometric measurements. The sonographic estimation which is based on measurement of various fetal dimensions particularly BPD, HC, AC and FL. The most popular formulae are Shepard, Warsof's with Shepard's modification and Hadlock’s. These formulae are included in most ultrasound equipment packages.

In urban setup, ultrasound is easily available for birth weight estimation. In rural setup such imaging modality are not easily available and clinical methods are still used by health workers for birth weight estimation as clinical methods of birth weight estimation don’t require any costly equipment and they are easy to use and give immediate estimation of expected birth weight.

METHODS

The study was conducted in Obstetrics and Gynecology Department, GMERS Medical College Hospital Sola, Ahmedabad, India. Antenatal patients with singleton live cephalic fetus with gestational age between 37 to 40 weeks attending Obstetrics and Gynecology Department of GMERS Medical College Hospital Sola, Ahmedabad were included over a period of 2 year from April 2014 to April 2016.

This was a prospective observational type of study.

The prevalence of full term antenatal patient in our institute was 30%. So, with 90% confidence interval and 5% allowable error, the desired sample size was as follows.

$N = p\ (1-p) \times z \div (me)^2$

Where, N = sample size, p = prevalence 30%, z = confidential limit which is 90%=1.645, me = margin of error-5%

So,

$N = 0.30\ (0.70)\ (1.645)\ 2 \div (0.05)\ 2 = 227$

Inclusion criteria

- Single live fetus
- Gestational age between 37 to 40 weeks
- Cephalic presentation

Exclusion criteria

- Multiple gestation
- Malpresentation
- Polyhydramnios
- Oligohydramnios
- IUGR
- Fibroids or adnexal mass
- Congenital anomalies

227 antenatal patients were included in this study as per inclusion criteria. All the eligible patients were given patient information sheet and were included in study after obtaining written informed consent.

The patient was then asked to empty her bladder and her symphysiofundal height (SFH) and abdominal girth (AG) were measured using a flexible, non-elastic, standard measure tape. Both measurements were performed with the patient lying flat on her back, with her legs extended. The SFH was measured from the midpoint of the upper border of the pubic symphysis to the highest point of the uterine fundus. For the AG measurement, the tape was repositioned to encircle the woman’s waist, at the level of the umbilicus, without applying pressure to tighten the tape around the abdomen. Then pelvic examination was performed to evaluate degree of descent(station) of the fetal head into the pelvis. Both measurements (SFH and AG) and information on the fetal station were recorded on the individual data sheet and later used to calculate the fetal weight according following formula:

1. Dare's formula: Weight in grams = AG x SFH

2. Johnson's formula: Weight in grams=155 x (SFH – X)

X=13 when presenting part at minus station, X=12 when presenting part is at 0 station, X=11 when presenting part is at plus station.

Then patient was subjected to ultrasound examination. It included electronic caliper measurement of the biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL) was carried out. The fetal weight was calculated automatically by the equipment, using Hadlock 4 formula which used BPD, HC, AC and FL.

$[\text{Log10BW} = 0.3596 + (0.00061 \times BPD \times AC) + (0.0424 \times AC) + (0.174 \times FL) + (0.0064 \times HC) - (0.00386 \times AC \times FL)]$.

Immediately after delivery birth weight estimation was done using a digital balance. If delivery did not occur within a week of estimations, the estimations were repeated and repeat estimations were taken in to consideration.

RESULTS

The demographic characteristics of the study population are shown in Table 1. In this study the mean maternal age was 25.63±3.68 years and the median was 25 years (range 18–35 years). The mean parity was 0.89±0.82 and the median was 1 (range 0-3). The mean maternal BMI was 21.57±2.49kg/m^2 and the median was 21.51kg/m^2 (range 15.4kg/m^2-31.39kg/m^2). The mean gestational age at the time of delivery was 38.73±0.83weeks and the median was 38.6 weeks (range 37-40 weeks).

Table 1: Demographic characteristics of study population.

	Mean±SD	Median	Range
Maternal age (year)	25.63±3.68	25	18-35
Parity	0.89±0.82	1	0-3
BMI (kg/$m^{2)}$	21.57±2.49	21.51	15.4-31.39
Gestational age at delivery (weeks)	38.73±0.83	38.6	37-40

Table 2 show underestimated and overestimated EBW with clinical and ultrasonographical methods. Number of over and under estimations by both clinical methods and USG was calculated. All three methods had a tendency to overestimate. Number of overestimated cases was least with USG (62.56%) as compared to Dare's formula and Johnson's formula (72.25% and 90.75% for Dare's formula and Johnson's formula respectively). Number of underestimated cases was least with Johnson's formula (8.81%) as compared to other methods (26.87% and 37% for Dare's formula and USG respectively). Number of correct estimation was more with Dare's formula (0.88%) as compared to other two methods (0.44 % with each method).

Table 2: Underestimated and overestimated EBW with various methods.

	Over estimated	Under estimated	Correctly estimated	Total
Dare's formula	164 (72.25%)	61 (26.87%)	2 (0.88%)	227 (100%)
Johnson's formula	206 (90.75%)	20 (8.81%)	1 (0.44%)	227 (100%)
USG	142 (62.56%)	84 (37.00%)	1 (0.44%)	227 (100%)

Table 3: Mean error of overestimation and underestimation by various clinical methods and USG.

Method	Mean error (gm)	
	Over estimation	Under estimation
Dare's formula	166.30	101.33
Johnson's formula	324.31	111.25
USG	102.37	74.85

Table 3 shows mean error of overestimation and underestimation by various clinical methods and USG. Mean error in over and under estimations was more in clinical methods than USG. In clinical methods, Dare's formula had low mean error. Mean error of over estimation were 166.30gm and 324.31gm for Dare's formula and Johnson's formula respectively. Mean error of over estimation for USG was 102.37gm which was least among all three method of fetal birth weight estimation. In case of under estimation, mean error was least with USG (74.85gm) as compared to clinical methods (101.33gm and 111.25gm for Dare's formula and Johnson's formula respectively).

Table 4: Maximum error in EBW calculated by various methods.

Method	Maximum error (gm)
Dare's formula	733
Johnson's formula	980
USG	527

Table 4 shows maximum error in EBW calculated by various methods. Maximum errors in EBW estimated by various methods were 733gm, 980gm and 527gm for Dare's formula, Johnson's formula and USG respectively.

Table 5 shows the mean fetal weight measured by clinical and ultrasound methods. The mean estimated birth weights (EBW) by Dare's formula, Johnson's formula and ultrasound were 2920±355gm, 3112±346gm and 2864±328gm respectively.

Table 5: The mean fetal weight measured by clinical and ultrasound methods.

	N	Mean ±SD	Minimum	Maximum	Paired T test	P value
EBW by Dare's formula (gm)	227	2920±355	2100	4000	8.781	<0.0001
EBW by Johnson's formula (gm)	227	3112±346	2170	4185	19.897	<0.0001
EBW by USG (gm)	227	2864±328	2082	3931	4.611	<0.0001

Mean of USG estimated EBW was closely resemble to mean of ABW (Table 6) but Paired *t*-test on mean ultrasonographically calculated weight taken before birth of fetus and actual birth weight revealed significant difference. (T test =4.611, P value <0.0001).

It was also found that actual birth weight was also significantly different from clinically estimated weight. (T test = 8.781, P value <0.0001 and T test=19.897, P value <0.0001 for Dare's formula and Johnson's formula respectively).

Table 6: The errors in Birth weight estimation by various methods compared to actual birth weight.

Error	Dare's formula	Johnson's formula	USG	P value of ANOVA
Mean error (gm)	-92.92 ±159.43	-284.51±215.43	-36.34±118.74	<0.0001
Mean absolute error (gm)	147.37±110.78	304.11±186.60	91.74±83.51	<0.0001
Mean percentage error (%)	-3.510±5.688	-10.529±7.983	-1.541±4.425	<0.0001
Mean absolute percentage error (%)	5.298±4.067	11.091±7.178	3.374±3.245	<0.0001

Table 6 shows the errors in Birth weight estimation by various methods compared to actual Birth weight. The mean error for Dare's formula, Johnson's formula and ultrasound were -92.92 ±159.43gm, -284.51±215.43gm and -36.34±118.74gm respectively. (Difference was statistically significant as P value <0.0001) The mean absolute error for Dare's formula, Johnson's formula and ultrasound were 147.37±110.78gm, 304.11±186.60gm and 91.74±83.51gm respectively. So, ultrasound had least mean absolute error. (Difference was statistically significant as P value <0.0001). The mean percentage error for Dare's formula, Johnson's formula and ultrasound were -3.510±5.688%, -10.529±7.983% and -1.541±4.425% respectively. (Difference was statistically significant as P value <0.0001). The mean absolute percentage error for Dare's formula, Johnson's formula and ultrasound were 5.298±4.067%, 11.091±7.178% and 3.374±3.245% respectively. So, ultrasound had least mean absolute percentage error (Difference was statistically significant as P value <0.0001).

Table 7: Correlation coefficient for birth weight estimation by various methods compared to actual birth weight.

	Dare's formula	Johnson's formula	USG
Correlation coefficient	+0.9026	+0.8182	+0.947

Table 7 shows the correlation coefficient for birth weight estimation by various methods compared to actual birth weight. A correlation coefficient is a number that quantifies some type of correlation and dependence, meaning statistical relationship between two observed data values. The stronger the association of the two observed data values, the closer the correlation coefficient will be to either +1 or -1 depending on whether the relationship is positive or negative respectively. The correlation coefficient for the Dare's formula, Johnson's formula and USG compared to actual birth weight were +0.9026, +0.8182 and +0.947 respectively, showing positive correlation with ABW. So, the strongest positive correlation with ABW was observed for USG, followed by Dare's formula.

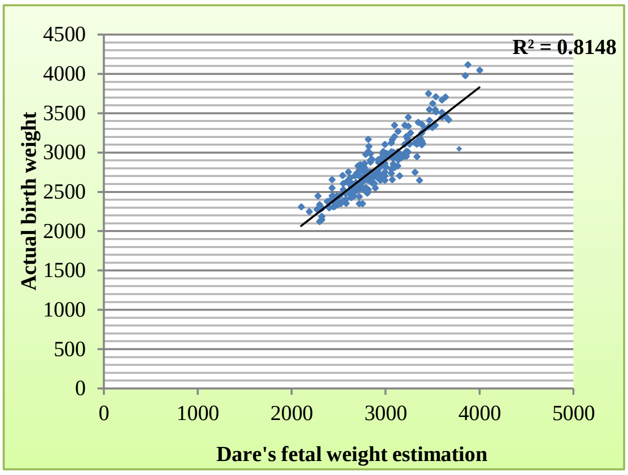

Figure 1: Scatter diagram of Dare's fetal weight estimation and ABW.

Figure 1 shows scatter diagram of Dare's fetal weight estimation and actual birth weight. X-axis has Dare's fetal weight estimations and Y-axis has ABW. In scatter diagram, if the pattern of dots slopes from lower left to upper right, it indicates a positive correlation between the variables being studied and if the pattern of dots slopes from upper left to lower right, it indicates a negative correlation. Coefficient of Determination (R^2) denotes the strength of the linear association between x and y. So, in above scatter diagram, as the pattern of dots slopes from lower left to upper right and R^2 value is 0.8148, Dare's fetal weight estimation shows strong positive linear correlation with the actual birth weight.

Figure 2 shows scatter diagram of Johnson's fetal weight estimation and actual birth weight. X-axis has Johnson's fetal weight estimations and Y-axis has ABW. In above scatter diagram, as the pattern of dots slopes from lower left to upper right and R^2 value is 0.6695, Johnson's fetal weight estimation shows positive linear correlation with the actual birth weight but strength of linear correlation is less than that of Dare's fetal weight estimation (R^2=0.8148).

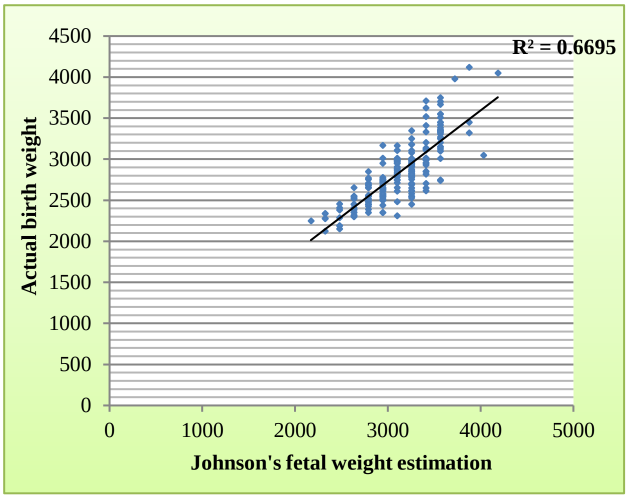

Figure 2: Scatter diagram of Johnson's fetal weight estimation and ABW.

Figure 3 shows scatter diagram of USG fetal weight estimation and actual birth weight. X-axis has USG fetal weight estimations and Y-axis has ABW. In above scatter diagram, as the pattern of dots slopes from lower left to upper right and R^2 value is 0.8969, USG fetal weight estimation shows strongest positive linear correlation with the actual birth weight among all three methods (R^2=8148 and R^2=0.6695 for Dare's formula and Johnson's formula respectively).

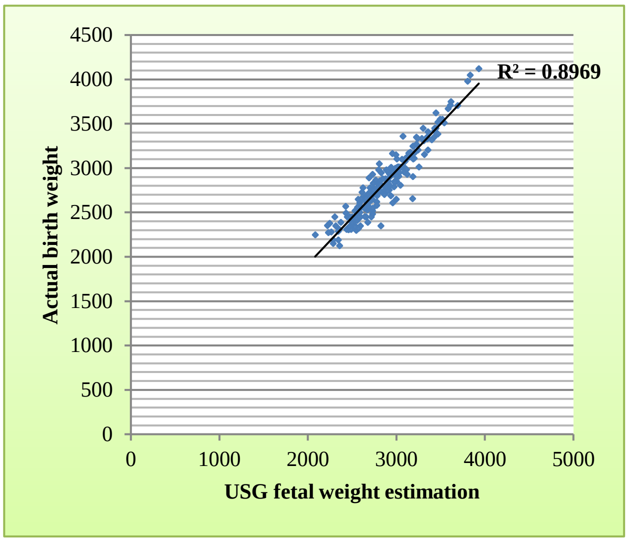

Figure 3: Scatter diagram of USG fetal weight estimation and ABW.

Table 8 shows error in percentage related to various methods of birth weight estimations. Estimations with error of <10% of ABW were most with USG (95.59%), closely followed by Dare's formula (90.31%). Johnson's formula had least number of such cases (only 48.90%). This difference was statistically significant. (P value 0.0000 by Chi square test). This difference was also statistically significant if we compared the Dare's formula alone with USG for such estimations (error <10% of ABW). (P value 0.02 by Chi square test). Estimations with error between 10 to 20% of ABW were most with Johnson's formula compared to other methods. USG had least number of cases (0.44%) with error of >20% of ABW among all 3 methods of birth weight estimations.

Table 8: Error in percentage related to various methods.

Error	Dare's formula N=227	Johnson's formula N=227	USG N=227
<10%	205 (90.31%)	111 (48.90%)	217 (95.59%)
10-20%	19 (8.37%)	91 (40.09%)	9 (3.97%)
>20%	3 (1.32%)	25 (11.01%)	1 (0.44%)

DISCUSSION

Njoku C et al had found that the mean estimated birth weights (EBW) by Dare's formula and Ultrasound were 3541±633gm and 3141±441gm respectively in their study.[11] They found that mean birth weight estimated by clinical method and USG were not statistically different from mean actual birth weight (P value were 0.695 and 0.122 for Dare's formula and USG respectively). In present study we found that the mean estimated birth weights (EBW) by Dare's formula, Johnson's formula and ultrasound were 2920±355gm, 3112±346gm and 2864±328gm respectively. We found that mean birth weight estimated by clinical method and USG were almost closer to mean actual birth weight, but they were statistically different from mean actual birth weight. (P value was <0.0001 for Dare's formula, Johnson's formula and USG). Raghuvanshi T et al had also found that mean of estimated fetal weight by Dare's formula (2696±394.2gm) and Hadlock's method (2574±357.1gm) were almost closer to the mean of actual birth weight (2593±427gm) but comparing each method with ABW, difference was found statistically significant with all three method of birth weight estimation (P value was 0.01 for each method).[12]

Amritha B et al had conducted a study for comparative analysis of accuracy of various method of birth weight estimation on 200 antenatal women. Standard deviation of prediction error was least with USG in their study (258.48gm).[13] Sowjanya R et al had conducted a prospective comparative study on 100 antenatal women.[14] They found that standard deviation of prediction error was least with Johnson's formula in their study (318.2 gm). Njoku C et al had found that standard deviation of prediction error was least with Dare's formula in their study (307gm).[11] In present study, standard deviation of prediction error was least with USG (83.51gm). Standard deviation prediction error with Dare's formula (110.78gm) was comparable to USG. It was highest with Johnson's formula (186.60gm). Njoku C et al had found that the mean error for Dare's formula and ultrasound were 299±338gm and −101±189gm respectively (Difference was statistically significant as P value 0.0000).[11] In present study, the mean error for Dare's formula, Johnson's formula and ultrasound were -92.92 ±159.43gm, -284.51±215.43gm and -36.34±118.74gm respectively (statistically significant as P value <0.0001).

Njoku C et al had found that mean absolute error was least with USG (293±313gm) as compared to clinical method but wasn't statistically significant. (P value 0.205).[11] In present study, mean absolute error was least with USG (91.74±83.51gm) as compared to clinical methods and was statistically significant (P value <0.0001). Njoku C et al had found that the mean percentage errors were 9.2±10.44% and −3.1±9.67% for Dare's formula and ultrasound respectively and this difference was statistically significant. (P value 0.0000).[11] In present study, the mean percentage errors were -3.510±5.688%, -10.529±7.983% and -1.541±4.425% for Dare's formula, Johnson's formula and ultrasound respectively and this difference was statistically significant. (P value <0.0001). Njoku C et al had found that mean absolute percentage error was least with USG (9.04±7.61%) as compared to clinical method but the difference was not statistically significant (P value 0.205).[11] In present study, we found that mean absolute percentage error was least with USG (3.374±3.245%) as compared to clinical methods and difference was statistically significant (P value <0.0001). Njoku C et al had found that correlation coefficient was more with USG (0.847) compared to Dare's formula in their study.[11] In present study we also found that correlation coefficient was highest with USG (0.947) closely followed by Dare's formula (0.902). So, both these methods had strong positive correlation with ABW. Maximum error in estimated birth weight was found highest with Johnson's formula among all three methods in studies conducted by Amritha B et al and Raghuvanshi T et al (1135gm and 1771gm respectively) while Sowjanya R et al had found maximum error in estimated birth weight with USG (712gm).[12-14] In present study, maximum error was found highest with Johnson's formula (980gm) among all three methods. Maximum error was least with USG (527gm) in present study.

Amritha B et al had found that Dare's formula had least average error (224.37gm) among the all three methods of birth weight estimations.[13] Sowjanya R et al and Raghuvanshi T et al had found that USG estimated EBW had least average error among all formula used (196gm and 131gm respectively).[12,14] Njoku C et al had also found that USG estimated EBW had least average error (293gm) among clinical and USG estimated EBW.[11] In present study, least average error (91.74gm) was found with USG estimated EBW among all three methods.

Number of cases with accuracy of fetal estimates within 10% of ABW was highest with Hadlock's formula in study conducted by Sowjanya R et al (77%), Raghuvanshi T et al (76%) and Njoku C et al (72%). Amritha B et al had found that fetal birth weight estimates within 10% of ABW was highest with Dare's formula (67%).[11-14] In present study we found 95.15% and 89.43% of cases with error of <10% ABW with Hadlock's formula and Dare's formula respectively. Johnson's formula had only 48.46% of cases with fetal birth weight estimates within 10% of ABW. Sowjanya R et al had found 35% of cases with error <100gm with Hadlock's formula in their study while Johnson's formula had only 28% cases having error <100gm.[14] In the present study, fetal estimates with error of <100gm were found most with USG (63%). Such cases were 35.68% and 12.77% with Dare's formula and Johnson's formula respectively.

CONCLUSION

Fetal birth weight estimation by USG using Hadlock 4 formula is more accurate than the birth weight estimation by clinical methods. Among the clinical methods, Dare's formula is more accurate than Johnson's formula. Average error in estimated birth weight compared to ABW is least with USG.USG is more accurate in estimating birth weight within 10% of ABW as compared to clinical methods. Among clinical methods of birth weight estimation, Dare's formula is more reliable. All three methods of birth weight estimations in this study have positive linear correlation with ABW. As the actual birth weight increases the estimation of birth weight by USG and clinical methods also increases.

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