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Original Research Article

Accuracy of Birth Weight Estimation by Clinical and Ultrasound Methods Among Term Pregnant Women at A District Hospital in Abuja, Nigeria.

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ABSTRACT

Background: Foetal weight estimation is an important component of maternity care. It is often estimated or predicted based on maternal parameters and foetal biometry, either clinically or with the aid of ultrasonography. Accurately estimating foetal weight is important for clinical concerns and safeguards from avoidable litigations. Objective: This study aimed to compare the accuracy of clinical and ultrasound estimation of foetal weight at term using actual birth weight as the baseline. Methodology: This was a cross-sectional comparative study in Asokoro District Hospital, Abuja. A clinically (Dare's method) estimated foetal weight was carried out, after which an ultrasound estimated (Hadlock-4 equation) foetal weight was performed. The actual birth weight was measured immediately after delivery. The estimated foetal weights were compared with the actual birth weight using standard accuracy measures. Data analysis was performed using IBM SPSS version 23. Results: The result of this study showed that there was no significant difference between the mean absolute percentage errors for the two methods of birth weight estimation at term (6.5 ± 5.94 vs. 5.4 ± 4.14, for Dare's clinical method and Hadlock-4 ultrasound, respectively, p=0.057). Both methods showed a strong positive linear correlation with actual birth weight (correlation coefficient 0.909 vs. 0.904, for Dare's formula vs. Hadlock-4 respectively). Conclusion: There is no significant difference between the accuracy of birth weight estimation using Dare's method and ultrasound scan (Hadlock-4). Therefore, both methods can be used according to the obstetrician's preferences and available resources.

Keywords: accuracy, actual birth weight, Dare's method, foetal weight estimation, Hadlock-4 equation

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INTRODUCTION

Foetal weight estimation is a crucial part of obstetric care management, especially in counselling, and planning mode of delivery.[1] There is an increased risk of complications such as cephalo-pelvic disproportion, shoulder dystocia, perinatal asphyxia, skull fracture, brachial plexus injuries, and subsequent life-long disabilities associated with both low and very large foetal weights at delivery which can lead to litigations.[1-3]Birth weight is one of the most important predictors and determinants of newborn survival.[2,3]

In-utero estimation of foetal weight is traditionally done with ultra-sonography or clinical methods. There are various clinical formulae for the prediction of foetal weight estimation, with each reported to have varying degrees of accuracy.[4,5,6] Foetal weight estimation can also be carried out with magnetic resonance imaging (MRI).[3,6] There are standard formulae, prefixed into the ultrasound scan machine, using foetal parameters for the calculation of foetal weight estimation. However, most of these formulae incorporate foetal biometry based on nomograms from data in developed countries. Besides, these formulae are obtained from populations that do not include pregnant women of all genetic backgrounds resulting in an inherent sampling error.[6,7] Bearing this in mind and the fact that there is a paucity of data about birth weight records in developing countries, coupled with the fact that the average weight of the newborn is not universally the same,[5] ultrasound scans estimated foetal weight may not be as accurate in the developing countries as in the developed countries.

Clinical estimation of foetal weight remains an alternative method of foetal weight estimation where ultrasound scan is not readily available or as a collaborative method of assessing foetal weight in busy obstetric centres where ultrasound scans are available but have a shortage of skilled manpower.[3,5] Foetal weight estimates using clinical methods are simple, fast, and do not require any special equipment,[4,5] and the skills of estimation are acquired through repeated performance and improved through experience.[8,9] In contrast, in developing countries, foetal weight prediction using ultrasound scans requires expensive equipment and is time-consuming.[4,5] The use of ultrasound scan for confirming fetal presentation, placental location, liquor volume etc is important in obstetrics, however, requesting time consuming, costly routine ultrasound just for the purpose of foetal weight estimation would be unwarrantable when clinically predicted foetal weight can be as accurate, and speedily done at practically no extra cost.[3,4]

The majority of studies comparing ultrasound and clinical estimation of foetal weight were done with ultrasound method using Hadlock-2 or Hadlock-3 formulae which might be responsible for the conflicting results.[1,3,10] Studies specifically using the Hadlock-4 formula ultrasound estimation of birth weight are quite limited with inconclusive results.[2, 8, 9] Hadlock-4 ultrasound formula measures multiple foetal parameters which may lead to more accurate measurements at term, especially when engagement has occurred.[1,3, 10] This study, is expected to add to the limited evidence on the comparison of the accuracy of Dare's clinical method for foetal weight estimation using the Hadlock-4 ultrasound formula for birth weight estimation. In addition, the study may reveal the relevance of Dare's clinical formula, for birth weight estimation against the backdrop of the use of the more expensive routine ultrasonography.

MATERIALS AND METHOD

We conducted a cross-sectional comparative study from the 1st of February 2019 to the 30th of June 2019 to compare the accuracy of the ultrasound scan method (Hadlock-4 formula: $\mathrm{Log10\ EFW} = 1.3596 - 0.00386(AC)(FL) + 0.0064(HC) + 0.0424(AC) + 0.174(FL) + 0.00061(BPD)(AC)$) of birth weight estimation with that of the clinical method (Dare's formula) of birth weight estimation using actual birth weight as the baseline, among pregnant women carrying singleton fetuses presenting cephalic at term (37 weeks to 42 weeks), at the Asokoro District Hospital, Abuja. Asokoro District Hospital is a public secondary healthcare facility owned by the Federal Capital Territory Administration (FCTA). The hospital has a total bed capacity of 120 with an average annual delivery rate of around 2000. Routine foetal weight estimation in the centre is by ultrasound method (Hadlock-2, Hadlock-3, and Hadlock-4). An obstetric ultrasound scan investigation costs two thousand Naira (₦2,000.00) only.

The study participants were recruited as they were admitted for delivery at term either by elective caesarean section or labour induction, or in early labour with evidence of intact membranes, and known gestational age estimated from either the first day of the last menstrual period or dating scan in the first trimester. Such participants would have given informed consent to participate in the study. Recruitment into the study was from the Antenatal Clinic, Labour Ward, or the Antenatal Ward in the hospital and it was by consecutive sampling method.

Subjects with abnormal lie or presentation, intrauterine growth restriction (IUGR), polyhydramnios, oligohydramnios, antepartum haemorrhage (APH), coexisting uterine fibroids, congenital anomalies (detected on ultrasound), intrauterine foetal death, and those who did not deliver within 24 hours of clinical or ultrasound foetal weight estimation were excluded from the study.

Estimate of Sample Size

The sample size was determined using the formula below **n =** $\underline{2SD^2 (Z_{1-\alpha/2} + Z_{1-\beta})^2}$ / d^2 for a two-tail test. For comparing 2 groups with quantitative endpoints.[11]
Where: **SD** is the presumed standard deviation, SD, of mean birth weight. SD = 0.361 from a related study.[3]
$Z_{1-\alpha/2}$ is the value of the normal distribution which cuts off an upper tail probability of α/2. It is a constant. Value is 1.96 at a 95% confidence interval, with α = 0.05
$Z_{1-\beta}$ is the value of the normal distribution which cuts off an upper tail probability of β. At the power of 80%, β = 0.2, and $Z_{1-\beta}$= 0.84
d = difference sought, (is the difference between means which was 0.1kg from a related study).[12]
An attrition rate of 15% was applied and a minimum sample size of 240 was calculated, however, 252 participants were recruited into the study.

Data Collection

A proforma was used to obtain each participant's information regarding demographics, parity, gestational age, obstetric history, and booking parameters were obtained from the women and were duly compared with antenatal records. To ensure adequate confidentiality in the process, serial identification numbers were assigned to participants.

Procedure for Clinical Estimation

Clinical birth weight estimation was done using Dare's method. [13] The method states that the foetal weight in grams is equal to the product of the symphysio-fundal height (SFH) and abdominal girth (AG) at the level of the umbilicus (EFW (Weight in Grams) = AG (cm) x SFH (cm)). The maternal parameters (AG, SFH) were measured using two surfaced non-stretchable tape and rounded off to the nearest centimetre. The symphysio-fundal height was measured from the highest point of the uterine fundus to the midpoint of the upper border of the symphysis pubis using the reverse side (inches surface) of the tape, to minimise measurement bias. Two different measurements were obtained for each participant, and the average was used as the final SFH to further minimise intra-observer error/variation. Thereafter, the abdominal circumference was measured immediately at the level of the umbilicus in centimetres also as described for the measurement of SFH. The foetal weight (in grams) was estimated using the formula described above. All clinical measurements were done by the investigators within 24 hours of delivery.

Procedure for ultrasound estimation.

After the clinical foetal weight estimation, an obstetric ultrasound scan was performed by the radiologists, who were blinded to the estimated clinical foetal weight. The obstetric scan to determine foetal weight estimation was carried out with an ultrasound machine (MindRay) model with the Hadlock-4 formula already incorporated. The Hadlock-4 regression formula was selected, which uses multiple foetal biometric parameters: biparietal diameter (BPD), abdominal circumference (AC), Femur length (FL), and Head circumference (HC). Hadlock-4 (AC-HC-BPD-FL): Log10 EFW = 1.3596 + 0.0064(HC) + 0.0424(AC) + 0.174(FL) + 0.00061(BPD)(AC) - 0.00386(AC)(FL).[14] A curvilinear probe was used to measure the fetal parameters.

The BPD was measured from the outer margin of the proximal skull table to inner margin of the distal table using electronic calipers. The measurement was taken at a level that showed the thalami, the carvum septi pellucidum, the intra-hemispheric fissure and the third ventricle. The measurement of head circumference was taken along the outer margin of the calvaria at the level of the biparietal diameter. The abdominal circumference was measured along the outer boundaries of the abdomen at the level of the portal vein complex using electronic callipers. The femur length was measured by identifying the full length of the femur. The measurement was taken along an axis that showed both the round femoral head and the femoral condyles.[15] The machine automatically generated the estimated foetal weight, which was recorded in the proforma for each participant. All measurements were done within 24 hours of delivery.

Measurement of the Actual Birth Weight.

After delivery, the actual birth weight (ABW) of each participant's neonate was measured within 30 minutes by the attending Resident Doctor, using a standardized digital neonatal weighing scale (Beurer) which measures in grammes to the nearest 5 g (0.005 kg) up to a maximum of 20 kg.

Data Analysis.

The values obtained were charted immediately against each participant's serial number on the proforma. All data collected were thereafter keyed into the Statistical Package for Social Sciences (SPSS) computer software version 23 for Windows.

A Shapiro-Wilk's test (p>0.05) and a visual inspection of the histograms, normal Q-Q plots, and box plots showed that the data were approximately normally distributed, with a skewness of 0.251 (SE = 0.153) and kurtosis of 0.583 (SE = 0.306) for Dare's method, and skewness of 0.103 (SE = 0.153) and kurtosis of 0.553 (SE = 0.306) for Hadlock-4 formula.[16]

The estimated foetal weight (EFW) for each method was compared with the actual birth weight (ABW) to the mean of simple error (EFW–ABW), mean of absolute error (absolute value of [EFW–ABW]), Mean percentage error, and mean of absolute percentage error (MAPE) (absolute value of [EFW–ABW] x 100/ABW). The MAPE reflects the variability in values noted irrespective of their direction (positive or negative). [17] The problem of positive and negative cancelling out each other was thus avoided with the use of MAPE.

The ability to correctly identify the birth weights within the actual birth weight ranges of low birth weight (<2500g), normal birth weight (2500-3999g), and macrosomia (≥4000g) was also determined for each method. This was used to determine the sensitivity, specificity, negative predictive power, positive predictive power, and diagnostic accuracy of each method of birth weight estimation.

The accuracy of each method of foetal weight estimation was determined using the mean absolute percentage error (MAPE), the ratio by percentage of estimate within 10% of actual birth weight, the sensitivity, specificity, positive predictive value, and negative predictive value. A Simple Scatter plot with a Fit Line of Actual birth weight by both Clinical Foetal weight estimate and also by ultrasound birth weight estimate was done. The accuracy of Dare's formula for birth weight estimation and Hadlock-4 ultrasound formula for birth weight estimation were compared using the students' t-test, Chi-square test, and Pearson's coefficient of correlation, and $p<0.05$ was considered statistically significant.

A predictive performance (receiver operating characteristics (ROC) curve, a plot of true positive rate against false positive rate) analysis was done for each method of foetal weight estimation.

Ethical Consideration.

Ethical clearance was obtained from the Health Research Ethics Committee of the Health and Human Services Secretariat of the Federal Capital Territory, Abuja, with the approval code: FHREC/2017/01/56/21-06-17. The nature and objective of the study were explained to each woman and consent was obtained before recruitment into the study. The women had the option to opt out of the study and this did not compromise the quality of care they received at any service point within the Asokoro district hospital.

RESULTS

A total of 252 eligible women, drawn from the major ethnic groups in Nigeria, participated in the study. The study population's demographic characteristics are shown in Table 1. The mean maternal age was 31.5 ±5.06 (range: 14-43) years. The majority of participants were married (93.3 %). All the study participants had formal education and the modal educational status was tertiary education (75.0%, 189/ 252). Their parity ranged from 0-4 with a mean parity of 1.4±1.25. The gestational age range at delivery was 37-42 weeks (mean 39.2±1.2 weeks).

Table 1. Demographic and clinical characteristics of study population (n=252)

Variable	Frequency	Percentage	Mean± Standard deviation
Maternal Age (years)			31.5 ±5.06
<20	1	0.4	
20-34	179	71.0	
35-49	72	28.6	
Ethnicity			
Hausa/Fulani	9	3.6	
Igbo	90	35.7	
Yoruba	39	15.5	
Others	112	44.4	
Foreigner	2	0.8	
Level of Educational			
None	0	0	
Primary	9	3.6	
Secondary	54	21.4	
Tertiary	189	75.0	
Occupation			
Public Servant	66	26.2	
Private Sector	61	24.2	
Self-employed	83	32.9	
Corps member/student	8	3.2	
Housewife	34	13.5	
Gestational age (weeks)			39.2 ± (1.2)
37-38	56	22.2	
39-40	136	54	
41-42	60	23.8	
Parity	Frequency	Percentage	1.4 ± (1.25)
0	76	30.2	
1-4	173	68.6	
≥5	3	1.2	
TOTAL	252	100	
Parameter	Range		
Symphysiofundal height (cm)	32- 47		37.6 ± 2.48
Abdominal Girth (cm)	81- 125		98.0 ± 6.62

Table 2 shows the frequency distribution of actual birth weights and birth weight estimates by ultrasound scan and clinical method. The actual birth weight showed there were 218 (86.5%) in the normal birth weight range of 2500 -3999g, and 29 (11.5%) and 5

(2%) in the macrosomic (≥4000g) and low birth weight (<2500g) respectively.

Clinical estimates showed there were 204 (81.0%) in the normal birth weight range and 48 (19.0%) in the macrosomic range but did not identify any of the fetuses in the low-birth-weight range.

Table 2: Foetal Weight Distribution by Clinical Method, Ultrasound, and Actual Birth Weight.

Birth weight categories	Actual birth weight Frequency (%)	USS FW estimate Frequency (%)	Clinical FW estimate Frequency (%)
Low birth weight <2500g	5 (2)	3 (1.2)	0
Normal birth weight 2500-3999g	218 (86.5)	210 (83.3)	204 (81.0)
Macrosomia ≥4000g	29 (11.5)	39 (15.5)	48 (19.0)

	N	Mean ± S. D	Minimum	Maximum	t-test	p-value
Actual birth weight	252	3501 ± 479g	2220	5150		
Clinical FW estimate	252	3681 ± 417g	2754	5336	14.254	<0.001
USS FW estimate	252	3585 ± 437g	2290	4970	6.566	<0.001

Ultrasound estimated 210 (83.3%) to be in the normal birth weight range, 39 (15.5%) in the macrosomic range, and 3(1.2%) in the low-birth-weight range

The mean actual birth weight was 3500.58±479.10 g, while it was 3585.40±436.10 g for ultrasound estimates and 3680.71±416.64 g for clinically measured estimates of birth weight. The paired t-test value and p-value were 14.254 and <0.001 respectively for clinical estimation of fetal weight, and 6.566 and <0.001 for ultrasound estimates of fetal weight when compared with actual birth weight.

The mean errors, correlation, validity, and accuracy of clinical and ultrasound estimates of foetal weight are shown in Table 3. Overall, the mean absolute percentage error for clinically estimated birth weight and ultrasound scan estimates of birthweight was 6.5±5.94 and 5.7 ± 4.14, respectively, and not statistically significant.

The correlation coefficient for clinically estimated foetal weight and ultrasound estimation of birth weight compared with actual birth weight was 0.909 and 0.904 respectively and statistically significant. Clinical foetal weight estimation with Dare's method showed a prediction to within 10% of actual birth weight of 83.3% of all estimates, while ultrasound estimation with Hadlock-4 formula was within 10% of actual birth weight of 86.5% of all estimates. In the normal birth weight range (2500 - 3999g), clinical foetal weight estimates and ultrasound estimates of foetal weight were within 10% of actual birth weight in 83.5% and 86.7% of cases respectively. In birthweight < 2500g, ultrasound estimates, and clinical estimates were within 10% of actual birthweight in 40% and 0% respectively. While in the macrosomic range, the clinical prediction to within 10% of actual birthweight was 96.6% and 93.1% respectively for clinical birth weight estimates and ultrasound estimates. However, the percentage of those in the low birthweight range and the macrosomic range

Table 3: The Means Errors, Correlation, And Accuracy of Ultrasound and Clinical Foetal Weight Estimation with the Actual Birth Weights of The Babies

Parameter	Clinical ± S. D	Ultrasound ± S. D	P-value
Mean error (gram)	180.13 ± 200.61	84.82 ± 205.06	<0.001
Mean absolute error (gram)	211.63 ± 166.90	182.80 ± 125.39	0.009
Mean percentage error	2.81 ± 6.23	5.7 ± 6.72	<0.001
Mean absolute % error	6.51 ± 5.94	5.43 ± 4.14	0.057
Correlation coefficient	0.909	0.904	<0.001, <0.001
Accuracy within 10% of ABW	83.3%	86.5%	
LBW <2500g	Clinical ±S. D	Ultrasound ±S. D	p-value
Mean error (gram)	561.60 ± 39.48	232.20 ± 114.39	0.004
Mean absolute error (gram)	561.60 ± 39.48	233.20 ± 114.39	0.043
Mean percentage error	24.38 ± 1.92	10.11 ± 5.02	0.005
Mean absolute % error	24.38 ± 1.92	10.11 ± 5.02	0.043
Correlation coefficient	0.940	0.716	0.018, 0.174
Accuracy within 10% of ABW	0%	40%	
Normal BW 2500-3999g	Clinical ±S. D	Ultrasound ±S. D	p-value
Mean error (gram)	187.85 ±188.99	102.33 ± 194.61	<0.001
Mean absolute error (gram)	208.40 ± 165.95	179.64 ± 126.38	0.014
Mean percentage error	5.85 ± 6.23	3.24 ±6.07	<0.001
Mean absolute % error	6.43 ± 5.63	5.44 ± 4.21	0.052
Correlation coefficient	0.845	0.844	<0.001, <0.001
Accuracy within 10% of ABW	83.5%	86.7%	
Macrosomia ≥4000g	Clinical ±S. D	Ultrasound ±S. D	p-value
Mean error (gram)	56.34 ± 203.45	-72.34 ± 222.83	0.005
Mean absolute error (gram)	175.59 ± 112.91	187.86 ± 120.53	0.619
Mean percentage error	1.33 ± 4.67	-1.62 ± 5.19	0.005
Mean absolute % error	4.05 ± 2.57	4.58 ± 2.82	0.673
Correlation coefficient	0.830	0.781	<0.001, <0.001
Accuracy within 10% of ABW	96.6%	93.1%	

ABW = Actual Birth Weight; LBW = Low Birth Weight; BW=Birth weight

was 2% and 11.5% respectively as against 86.5% in the normal birthweight range.

Table 4: The validity of clinical and ultrasound fetal weight estimation.

Validity	Clinical method	Ultrasound method
Low Birth weight estimation		
Sensitivity	0	60.0%
Specificity	100%	99.6%
Positive predictive value (PPV)	0	66.7%
Negative predictive value (NPV)	98%	98.8%
Diagnostic accuracy	98%	98.4%
Normal Birth weight		
Sensitivity	90.4%	91.7%
Specificity	79.4%	70.6%
Positive predictive value (PPV)	96.6%	95.2%
Negative predictive value (NPV)	56.3%	57.1%
Diagnostic accuracy	88.9%	88.9%
Macrosomic Birth weight		
Sensitivity	93.1%	75.9%
Specificity	90.6%	92.4%
Positive predictive value (PPV)	56.3%	56.4%
Negative predictive value (NPV)	99.0%	96.7%
Diagnostic accuracy	90.9%	90.5%

Table 5: Data for the Receiver Operating Characteristics (ROC) Curve for clinical and ultrasound methods of foetal weight estimation.

Test Result Variable(s)	Area Under the Curve	Std. Error	p-value	95% Confidence Interval	
				Lower	Upper
Clinical Fetal weight estimate	0.766	0.044	< 0.001	0.679	0.853
USS Fetal weight estimate	0.789	0.042	< 0.001	0.707	0.870

Figures 1 and 2 are Simple Scatter with Fit Line diagrams that show the relationship between actual birth weight and clinical method (figure 1) and ultrasound estimation (figure 2) of birth weight estimations respectively.

Both methods of birth weight estimation showed strong positive correlations with the actual birth weight of the foetus after delivery, with correlation coefficients of 0.830 and 0.781 respectively for clinical and ultrasound estimates of birth weight. They show that a rise in actual birth weight was paralleled by a corresponding rise in both clinical and ultrasound birth weight estimates respectively.

The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of ultrasound with Hadlock-4 formula and clinical estimates of foetal weight with Dare's method in birth weight range are shown in Table 4.

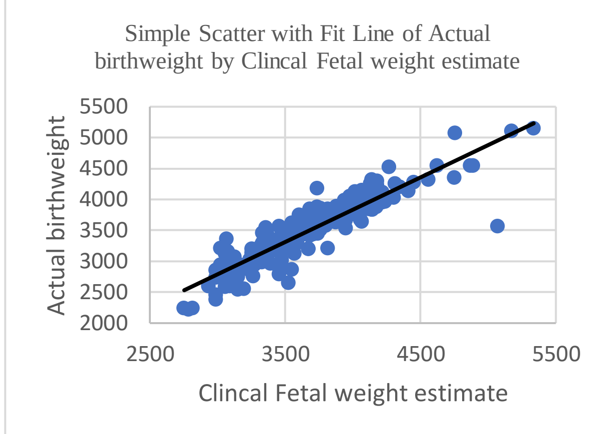

Figure 1: Relationship between actual birth weight and weight obtained by clinical estimation.

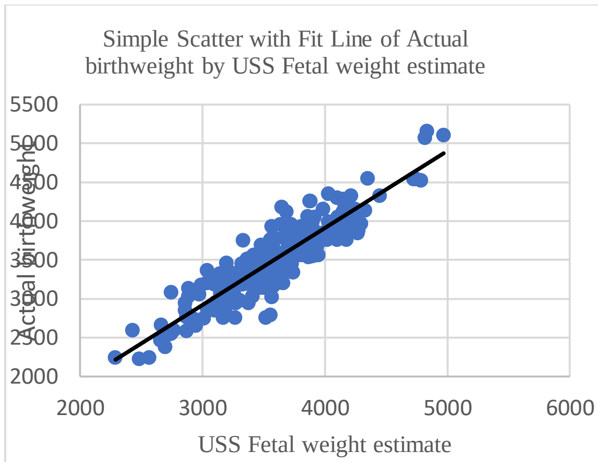

Figure 2: Relationship between actual birth weight and weight obtained by ultrasound (Hadlock-4) estimation.

In the normal birth weight range of 2500-3999 g ultrasound estimates with the Hadlock-4 formula correctly predicted 200 out of the 218 fetuses to be within the normal birth weight but wrongly estimated 7 fetuses in other birth weight ranges to be within normal birth weight range giving it a sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 91.7%, 70.6%, 95.2%, 57.1% and 88.9% respectively.

In the low birthweight of <2500 g, the ultrasound foetal weight estimates were correctly predicted in 2 of the 5 low birth weight babies, but one normal weight baby was wrongly identified as a low birth weight giving it a sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 60.0%, 99.6%, 66.7%, 98.8%, and 98.4% respectively. In the macrosomic birthweight range (≥4000g), the ultrasound foetal weight estimates correctly identified 22 out of the 29 babies in the actual macrosomic birth weight range giving it a sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 75.9%, 92.4%, 56.4%, 96.7% and 90.5% respectively.

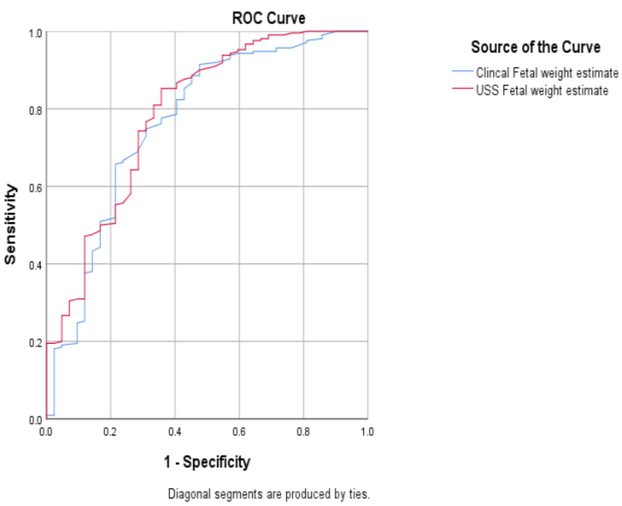

Figure 3: Receiver Operating Characteristics (ROC) Curve for clinical and ultrasound methods of foetal weight estimations.

In the normal birth weight range of 2500-3999g, Dare's method was used to correctly identify 197 out of the 218 of fetuses with actual birth weight, but wrongly identified 5 fetuses in other birth weight ranges to be in normal birth weight range giving it a sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 90.4%, 79.4%, 96.6%, 56.3% and 88.9% respectively.

Dare's clinical weight estimation correctly excluded all low-birth-weight babies but did not identify any of the 5 babies in the low-birth-weight range giving it a sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 0%, 100%,0%, 98% and 98% respectively.

Dare's clinical method correctly predicted 27 of the 29 macrosomic babies and wrongly identified 21 babies from other birth weight ranges as macrosomic babies giving it a sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of 93.1%, 90.6%, 56.3%, 99.0% and 90.9% respectively.

Figure 3 and Table 5 show the Receiver Operating Characteristics *Curve* (ROC) for both methods of foetal weight estimations. Both clinical estimates and ultrasound estimates of birth weight described good curves, with areas under the curve (AUC) of 0.766 and 0.789, and *p*-values <0.001 for both methods respectively.

DISCUSSION

This study did not show any significant difference between the accuracy of the ultrasound scan method (Hadlock-4 formula) of birth weight estimation and the clinical method (Dare's formula) of birth weight estimation using actual birth weight as the baseline, among pregnant women carrying singleton fetuses presenting cephalic at term at the Asokoro District Hospital, Abuja.

The demographic characteristics of the study population showed that every subject was literate, with 75% of the study population having a tertiary level of education. This differs from the work of Ugwu, et al. in Kano where 49.5% had tertiary education.[5] This might be because Asokoro District, Abuja, is mainly a civil service town, while Kano is more cosmopolitan. The mean actual birth weight of 3680.71 ± 416.64 g is comparable to the mean actual birth weight of 3594.17 ± 462.86 g reported by Okonta et al,[9] while sharply contrasting with findings from other studies in similar settings.[2,18] This might be a result of multiple factors, such as the sample size and distribution of the study population, as well as socio-economic and ethnic differences. Both methods of birth weight estimation showed mean estimates close to actual birth weight, but the mean birth weight estimate with the ultrasound measurement (Hadlock-4 formula) was closer to the actual mean birth weight estimate than the mean clinical birth weight (Dare's formula) estimate. This finding agrees with the findings of Okonta et al in Warri, South-south Nigeria. However, the sample size was smaller in the study by Okonta et al and the mean differences between the clinical foetal weight estimates, the mean ultrasound birth weight estimates, and actual birth weight did not show significant statistical differences.[9]

Our study shows that Dare's formula for birth weight estimation demonstrated a strong positive linear correlation with actual birth weight which is in keeping with the findings in several similar studies.[12,19,20] However, the value observed in our study was lower than those recorded in some studies,[1,3] a difference that may be accounted for by our smaller sample size.

The finding from our study shows that the overall MAPE for birth weight estimation with Dare's method was comparable with actual birth weight. However, the MAPE was much higher in the low-birth-weight range and slightly lower in the macrosomic range. The estimates with Dare's formula that were within 10% of actual birth weight in the macrosomic range was high (96.9%) but none was recorded in the low-birth-weight range, indicating a marked overestimation in the low-birth-weight range. Dare's formula for clinical estimation of birth weight predicted 83.3% of all estimates to be within 10% of actual birth weight. The difference between the actual birth weight and estimates with Dare's method was, however, statistically significant (p< 0.001). The correlation coefficient between ultrasound (Hadlock-4 formula) birth weight estimation in our study is higher than values recorded in some studies with smaller sample sizes[7,9,14,20,21] but lower than that obtained in a similar study where a larger sample size was used. [7]

The overall MAPE for birth weight estimates with the Hadlock-4 method is comparable with that of actual birth weight in the normal birth weight range of 2500 – 3999 g (5.43 ± 4.14 vs 5.44 ± 4.21). The MAPE was higher in both the low-birth-weight range and macrosomic range estimates. Hadlock-4 formula overestimated the birthweight in the low birthweight range while underestimating it in the macrosomic range. Overall, the percentage of ultrasound birthweight estimates with Hadlock-4 correctly predicted the birth weight to be within 10% of the actual birth weight in 86.5% of the neonates, which showed a statistically significant difference from the actual birth weight and higher than values from similar studies. [2,9,12]

Both methods of birthweight estimation showed a strong positive linear correlation and statistical correlation with the actual birth weight which suggests a consistent rise in the birth weight estimation using both methods as actual birth weight increases. In our study, values >0.75 imply strong agreement between the parameters being compared. However, different Authors have used different measures of accuracy to determine the accuracy of birth weight estimations using ultrasound scans and clinical methods with actual birth weight as gold standards. The measures of accuracy used in previously conducted related studies include estimation to within 10% of actual birthweight and the MAPE.[1-3,12,22,23]

Our study shows that both methods of birth weight estimation recorded highly accurate predicting ability (MAPE < 10), with no statistically significant difference, though Hadlock-4 estimation (5.43 ± 4.14) showed a lower MAPE compared with Dare's formula (6.51 ± 5.94). These values are similar to findings from some related studies in similar settings. [20,25]

In a related study in India, Prajapati et al,[25] recorded lower MAPE values compared to our study However, their sample size was smaller, and the study population was similarly different.

In various categories of birth weight, the MAPE values reported by other investigators did not differ much from the values obtained in this study.[2,9,12]

In the normal birth weight range of 2500 – 3999 g, ultrasound estimates had a smaller MAPE than clinical estimates, but both methods showed high predicting ability (MAPE < 10), and there was no statistical difference. In low-birth-weight neonates, Hadlock-4 estimation showed a good predicting ability (MAPE 10-20), while Dare's method showed a reasonable predicting ability (MAPE > 20 but < 50), and the difference was statistically significant. Similarly, the MAPE obtained in our study in the macrosomic range was highly accurate (MAPE<10) and similar for both methods of birth weight estimation, with no statistically significant difference. However, the number (n = 5) of neonates with actual birth weights in the low-birth-weight range was smaller compared with those that were macrosomic (n=29) and/or in the normal birthweight (n = 218) range. This may explain the high MAPE obtained in the LBW range; thus, MAPE obtained for the estimates in the low-birth-weight range needs to be interpreted with caution. Overall, the difference between the MAPE for Dare's clinical method and Hadlock-4 ultrasound formula estimation was not significant, in keeping with the findings in other studies.[2,9,12]

From our study, the percentage estimates within 10% of actual birth weight using Dare's formula for clinical estimation of birth weight is slightly lower than that obtained using the Hadlock-4 ultrasound formula, but both showed statistically significant differences from the actual birth weight (*p* < 0.001, p < 0.001 respectively). Overall, compared with similar studies in the same setting,[9,25] our study shows higher values of percentage estimates within 10% of actual birth weight for both clinical and ultrasound methods of birthweight estimates. Again, the relatively smaller sample sizes of these studies compared to ours must be taken into consideration when interpreting these results, especially the work of Okonta et al where the sample size was 60. [9]. The studies by Bajaj et al[26] and Parvathavarthini et al.[27] recorded much lower values (68% and 67% and 45% and 39% respectively) than our study.

The finding from our study shows that the two methods have similar sensitivity, positive predictive values, negative predictive values, and diagnostic accuracy for estimating birth weight in the normal birth weight range of 2500 – 3900 g, while Dare's method showed a higher specificity than Hadlock-4 formula in the same birthweight range. It is also worthy of note that both methods showed similar but low negative predictive values for estimating actual birth weight, whilst showing very high positive predictive values, in the same normal birth weight range. The sensitivity of Dare's clinical method and Hadlock-4 ultrasound method for estimating actual birth weight in the normal birth weight range of 2500-3999g, in this study, corroborates the reported values for both methods in similar studies.[12,28]

In low-birth-weight fetuses, Dare's Clinical formula showed a much lower sensitivity and positive predictive value compared to the Hadlock-4 ultrasound formula which is in contrast to that reported by Ugwa et al. [12] However, the number of low-birth-weight neonates in both studies was small (5 fetuses for both), so this result should be interpreted cautiously. In a related study by Ingale et al, Dare's clinical method demonstrated a sensitivity of 48% for predicting low-birth-weight babies, and 20% for the ultrasound scan method using Hadlock-4 formula. [28] However, that study had a larger number of babies with low birth weight than our study (25 vs. 5). In a study conducted by Mortazavi et al (n=795),[20] the sensitivity of Dare's clinical method to predict low birth weight fetuses was 70.4%, which was higher than the value in our study and that of Ugwa et al.[12]

The low sensitivity of both methods, especially Dare's clinical measurement, to predict low-birth-weight fetuses may be due to the small number of low-birth-weight babies in this study. The specificity of Dare's clinical formula and Hadlock-4 ultrasound formula for predicting birthweight below 2500g was almost identical (100% vs. 99.6%). These values were greater than the values obtained in other related studies.[24,29] The positive predictive value was higher with ultrasound scan (Hadlock-4) birth weight estimation than with Dare's clinical method for birth weight estimation. On the other hand, the two methods showed similar negative predictive values and similar diagnostic accuracy in the low-birth-weight range. In terms of positive predictive value and sensitivity, Hadlock-4 ultrasound estimation of birth weight was superior to Dare's clinical formula for estimation of birth weight in low-birth-weight fetuses.

In the macrosomic birth weight range, Dare's clinical method for birth weight estimation showed a higher sensitivity for predicting actual birth weight than Hadlock-4 ultrasound estimates. However, the two methods showed similar specificity, positive predictive values, negative predictive values, and diagnostic accuracy. However, the positive predictive value of either of the two methods of birth weight prediction was low. These findings are in contrast to the findings of Ugwa et al and Ingale et al[12,28] with the former reporting higher positive predictive values for both Dare's formula and Hadlock-4 ultrasound estimation, and the latter reporting a-zero sensitivity for Dare's formula, while ultrasound estimates showed a sensitivity of 40% in the same birth weight range. Overall, our study shows similar diagnostic power for estimating actual birth weight with Dare's method and ultrasound method (Hadlock-4) with that of Ugwa et al.[12]

Using the ROC curve, our study reveals that the 2 methods showed similar curves and areas under curve (AUCs), with none describing an excellent or ideal curve. An accurate method for estimating fetal weights should result in a ROC curve that rises vertically along the y-axis and then continues in parallel to the x-axis.[30] An area under the curve of 1 represents a perfect test; an area of 0.5 shows a worthless test. The AUC was 0.766 vs. 0.789 for clinical and Hadlock-4 respectively, in our study. An area of 0.7-0.8 shows a fair result, while a good test will describe an AUC of 0.8-0.9. None of the 2 methods in our study produced AUC very close to 0.9-1 and thus did not show a perfect prediction method for actual birth weight with either the clinical (Dare's) or ultrasound (Hadlock-4) method. This finding differs from the findings of Lanowski et al,[8] which showed that ultrasound birth weight estimation with Hadlock-4 described an excellent ROC curve, and a larger AUC when compared with birth weight estimation with Dare's formula. This tends to suggest that ultrasound method is superior to the clinical (Dare's) method in estimating actual birth weight. However, their study had a relatively smaller sample size (n=204) compared to our study (n=252).[8]

CONCLUSION

Our study has demonstrated that there is no difference between the accuracy of clinical (by Dare's formula) and ultrasound (using Hadlock-4 formula) methods of estimating actual birth weight among term pregnant women with singleton fetuses in cephalic presentation. Therefore, Dare's clinical measurement for birth weight estimation can be considered a good screening method in normal birth weight fetuses and is recommended for use by both Obstetricians and midwives, especially in resource-limited settings where ultrasound scans are not readily available or affordable.

Further studies with larger sample sizes for fetuses at the extremes of birth weight may be needed to improve the accuracy of both methods at predicting birth weight in the said birth weight ranges

Limitations of Study

The research is a single-centre study and involved the use of a consecutive sampling technique and a relatively small sample size which may make the results less generalizable.

REFERENCES

1. Ugwu EO, Udealor PC, Dim CC, Obi SN, Ozumba BC, Okeke DO, et al. Accuracy of clinical and ultrasound estimation of fetal weight in predicting actual birth weight in Enugu, South-eastern Nigeria. Niger J Clin Pract. 2014; 17(3):270-5.
2. Njoku C, Emechebe C, Odusolu P, Abeshi S, Chukwu C, Ekabua J. Determination of Accuracy of Fetal Weight Using Ultrasound and Clinical Fetal Weight Estimations in Calabar Southsouth Nigeria. Int Sch Res Notices 2014;

2014: 970973. Available from: http://dx.doi.org/10.1155/2014/970973

3. Shittu AS, Kuti O, Orji EO, Makinde NO, Ogunniyi OS, Ayoola OO, et al. Clinical versus sonographic Estimation of Foetal Weight in Southwest Nigeria J Health Popul Nutr. 2007; 25(1):14-23.
4. Torloni MR, Sass N, Sato JL, Renzi ACP, Fukuyama M, Lucca PR. Clinical formulas, mother's opinion and ultrasound in predicting birth weight. Sao Paulo Med J. 2008; 126(3): 145-149.
5. Ugwa EA. Advances in the clinical estimation of foetal weight before delivery. Niger J Basic Clin Sci. 2015; 12(2):67-73
6. Sharma N, Srinivasan JK, Sagayaraj BM, Lal DV. Foetal weight estimation – clinical, sonographic and MRI Imaging. Int J Sci Res Publications. 2014; 4(1):2250-3153. Available from: www.ijsrp.org
7. Dudley NJ. A systematic review of the ultrasound estimation of fetal weight. Ultrasound Obstet Gynecol. 2005; 25(1): 80–89. Available from: https://doi.10.1002/uog.1751
8. Lanowski J, Lanowski G, Schippert C, Drinkut K, Hillemans P, Staboulidou I. Ultrasound versus Clinical examination to Estimate Fetal Weight at Term. Geburtsh Frauenheilk. 2017; 77(3):278-283
9. Okonta PI, Nwachi A, Onyemesili C.A Comparison of Clinical and Ultrasound Estimation of Fetal weight at a secondary Health Care Facility in Nigeria. Afr J Trop Med & Biomed Res. 2013; 2(2): 10-19
10. Mgbafulu CC, Ajah LO, Umeora OU, Ibekwe PC, Ezeonu PO, Orji M. Estimation of fetal weight: a comparison of clinical and sonographic methods. J Obstet Gynecol. 2019; 39(5).639-646. [Online]. available from: https://doi.org/10.1080/01443615.2019.1571567 (accessed on August 20th, 2020)
11. Senn SJ. Statistical issues in drug development: Determining the Sample Size. 2nd ed. Chichester: Wiley; 1997:196-211.
12. Ugwa EA, Sule G, Ashimi A. Estimation of fetal weight before delivery in low-resource setting of North-west Nigeria: Can we rely on our clinical skills? J Matern Fetal Neonatal Med. 2014; 28(8):949-953
13. Dare FO, Ademowore AS, Ifaturoti OO, Nganwuchu A. The value of symphysiofundal height/abdominal girth measurement in predicting fetal weight. Int J Gynaecol Obstet 1990; 31(3):243-248.
14. Hadlock FP, Harrist RB, Sharman RS, Deter RL, Park SK. Estimation of fetal weight with the use of head, body, and femur measurements–a prospective study. Am J Obstet Gynecol 1985; 151(3): 333–337.
15. Salomon LJ, Alfirevic Z, Silva Costa FD, Deter RL, Figueras F, Ghi T et al. ISUOG Practice Guidelines: Ultrasound assessment of fetal biometry and growth. Ultrasound in Obstetrics & Gynecology 2019; 53(6):715-723. https://doi.org/10.1002/uog.20272
16. Razali NM, Wah YB. The power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. J Stat Model Analytics 2011; 2(1):21-33.
17. Moreno JJ, Pol AP, Abab AS, Blasco BC. Using the R-MAPE index as a resistant measure of forecast accuracy. Psicothema. 2013; 25(4):500-506.
18. Yilgwan CS, Utoo TB, Hyacinth HI. Maternal characteristics influencing birth weight and infant weight gain in the first 6 weeks post-partum: A cross-sectional study of post-natal clinic population. Niger Med J. [online]. 2012; 53(4):200-205. Available from: http://www.nigeriamedj.com/test.asp/2012/53/4/200/107553. Accessed online on October 16th, 2019.
19. Hadlock FP, Harrist RB, Carpenter RJ, Deter RL, Park SK. Sonographic estimation of fetal weight: the value of femur length in addition to head and abdominal measurements. Radiology 1984; 150(2):535-540.
20. Mortazavi F, Akaberi A. Estimation of birth weight by measurement of fundal height and abdominal girth in parturients at term. East Mediterr Health J. 2010;16(5): 553-557
21. Farrell T, Holmes R, Stone P. The effect of body mass index on three methods of fetal weight estimation. BJOG. 2002;109(6): 651–657
22. Durbin A, Lee C, Parker V. The effect of amniotic fluid index on the accuracy of sonographic estimated fetal weight. J Diagn Med Sonogr 2005; 21(4): 329–335.
23. Predanic M, Cho A, Ingrid F, Pellettieri J: Ultrasonographic estimation of fetal weight: acquiring accuracy in residency. J Ultrasound Med. 2002; 21(5):495–500.
24. Ashrafganjooei T, Naderi T, Eshrati B, Babapoor N. Accuracy of ultrasound, clinical and maternal estimates of birth weight in term women. EMHJ. 2010; 16(3): 14 – 318.
25. Prajapa DG, Patel RM. Comparison of various methods of fetal birth weight estimation in term pregnancy. Int J Reprod Contracept Obstet Gynecol. 2018; 7(3):1058-1064.
26. Bajaj P, Kadikar GK, Kannani M, Bhatt M, Shah S. Estimation of foetal birth weight clinically and sonographically and its correlation with its actual birth weight: a prospective and comparative study. Int J Reprod Contracept Obstet Gynecol. 2017; 6:3103-8.
27. Kathiriya D, Patil Y, Patange RP. Comparative Study of Various Methods of Fetal Weight Estimation at Term Pregnancy. International Journal of Recent Trends in Science and Technology. 2014; 9(3): 453-456.
28. Ingale A, Khade SA, Shirodkar S. Clinical versus ultrasonographic fetal weight estimation and its correlation with actual birth weight. Int J Reprod Contracept Obstet Gynecol. 2019; 8(2):503-512.
29. Bajracharya J, Shrestha NS, Karki C. Accuracy of Prediction of Birth Weight by Fetal Ultrasound. Kathmandu Univ med J. 2012; 38(2):74-76.
30. Tripepi G, Jager KJ, Dekker FW, Zoccali C. Diagnostic methods 2: receiver operating characteristic (ROC) curves. Kidney International 2009; 76(3):252–256