Accuracy of clinical and ultrasound estimation of fetal weight in predicting actual birth weight in Enugu, Southeastern Nigeria

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Abstract

Background: Estimation of fetal weight is important for antenatal and intrapartum management of pregnant women. Sonographic methods are not readily accessible in under-resourced settings, it is therefore necessary to study the accuracy of a clinical method of estimating fetal weight where this limitation (unavailability of ultrasound) exists.
Objective: To compare the accuracy of clinical and ultrasound methods of fetal weight estimation at term.
Materials and Methods: Clinical and ultrasound fetal weights were estimated on 200 consecutive term pregnancies (37 completed weeks of gestation - 41 weeks and 6 days) at the University of Nigeria Teaching Hospital, Enugu, Nigeria from 1st April to 30th November 2012. Accuracy was determined using percentage error, absolute percentage error, and proportion of estimates within 10% of actual birth weight.
Results: Actual birth weight had strong positive correlation with both clinical and ultrasound estimated fetal weights ($r = 0.71$, $P < 0.001$ and $r = 0.69$, $P < 0.001$, respectively). Overall, both the clinical and ultrasound methods systematically overestimated the actual birth weight. The proportion of the clinical estimated weights that were within 10% of the actual birth weight was significantly lower than that of ultrasound method for babies of all birth weights (35.0 vs. 67.5%; $P < 0.001$) and for macrosomic babies (76 vs 100%, $P = 0.009$). For babies with normal birth weights (2.5-3.9 kg), ultrasound method error values were significantly lower than those of clinical method for both the mean % error (5.4 vs 19.6%; $P < 0.001$) and the mean absolute % error (9.97 vs 20.6%; $P < 0.001$).
Conclusion: The ultrasound method is generally a better predictor of the actual birth weight than the clinical method, and thus should be used in estimating the actual birth weight when accessible.

Key words: Birth weight, clinical estimation, Nigeria, ultrasound estimation

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Introduction

Estimation of fetal weight is an important component of maternity care management especially in counseling, differential diagnosis, and planning of delivery mode.[1] Accurate estimation of fetal weight is therefore of paramount importance in the management of labor and delivery.[2] Basically, there are three groups of birth weights that are important to the clinicians; thus, the low birth weight, the normal birth weight, and the macrosomic babies. Since neonatal complications are more associated with low birth weight,[3] and labor abnormalities as well as neonatal complications with fetal macrosomia,[4] accurate estimation of fetal weight is of greater importance in taking management decisions as regards delivery of these extremes of fetal weight.

Furthermore, when there is likelihood of delivering a very low birth weight baby (as in preterm delivery), prenatal

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counseling on likelihood of survival, optimal route of delivery, or the level of hospital where delivery should occur may be based wholly, or in part on the estimation of the expected birth weight.[2] Very low birth weight babies delivered vaginally may be predisposed to skull injuries, limb fractures, and trauma to the abdominal organs such as the spleen and liver as a result of prematurity. The perinatal morbidity and mortality rates are very high in our environment and this problem is largely related to prematurity and low birth weights which are the most important parameters that determine neonatal survival.[5,6] Accurate estimation of birth weight is equally important when considering the mode of delivery in these situations; for instance, cesarean delivery for extreme preterm babies with the associated very low birth weight and obvious low chance of survival in poor resourced settings, may not be very justifiable. This consideration is more important in our environment where high aversion for caesarean delivery is prevalent.[7] Likewise, management of the very low birth weight neonate needs a specialized care in centers with good neonatal facilities; therefore, when the weight of a fetus is estimated to be very low, its delivery should be planned to take place in such a center so as to increase the chance of survival.

On the other hand, detection of fetuses who will have birth weights of at least 4,000 g is important because birth weights in excess of 4,000 g have been associated with prolonged labor, operative or traumatic delivery, and fetal neurologic injury.[8] Conditions that may raise high index of suspicion of macrosomia include diabetes mellitus in pregnancy, history of delivery of macrosomic babies in previous pregnancies, genital tract laceration in previous pregnancies, and difficult deliveries including shoulder dystocia in previous pregnancies. In order to prevent the adverse consequences of macrosomia in such cases, accurate estimation of fetal weight is of utmost importance. Likewise, accurate estimation of fetal weight is also very important in planning for a vaginal birth after a previous cesarean section and in intrapartum management of fetuses presenting breech.

The burden of extreme fetal weight on maternal and neonatal health has thus necessitated research into accurate ways of estimating fetal weight especially when estimation of fetal weight would help in taking appropriate management decisions. Consequently, several studies have compared the accuracy of clinical and ultrasound methods of fetal weight estimation.[2,9-11] Unfortunately, none of these studies conclusively stated that a particular method of fetal weight estimation is totally better than the other in predicting the actual birth weight in the three categories of birth weights, and the studies appear to show some geographical variations. Often times, either ultrasound method or clinical method was found to be better in predicting the actual birth weight in one or two categories of birth weights, but rarely in all the three categories. Since the sonographic estimates may not always be readily available in low resource settings including Nigeria, it is essential to study the accuracy of clinical estimation of fetal weight in predicting the actual birth weight as this will help in making appropriate management decision for pregnant women in our environment. This study therefore aimed at determining the accuracy of clinical method of fetal weight estimation in comparison with the ultrasound method in predicting the actual birth weight among pregnant women in Enugu, southeastern Nigeria.

Materials and Methods

This was a prospective cross-sectional study of consecutive term pregnant women attending the antenatal clinic of the University of Nigeria Teaching Hospital (UNTH) Enugu, Nigeria from 1st April 2012 to 30th November 2012. Ethical clearance for the study was obtained from the Institutional Review Board of the UNTH, Enugu.

All the patients were adequately counseled and their written consents obtained before recruitment into the study. The inclusion criteria were term singleton pregnant women in early labor, or booked for labor induction, or elective cesarean section. The exclusion criteria were: Maternal obesity (absolute weight ≥ 95 kg),[12] premature rupture of membranes, antepartum hemorrhage, congenital anomalies (detected on ultrasound), unstable patients such as eclamptics, and delivery after 72 h of clinical or ultrasonic fetal weight estimation.

A related study from Nigeria found that the standard deviation (SD) of mean birth weight of newborns was 0.662 kg.[2] Therefore, a sample size of 211 women used for this study was adequate to identify a minimum meaningful mean weight difference of 0.18 kg at a 95% confidence level, 80% power, and assumed attrition rate of 10%.

Following an informed consent, the Dare's formula[13] was used to estimate the clinical fetal weight of participants at the antenatal ward or labor ward depending on the indication for admission. The formula states that the fetal weight in grams is equal to the product of the symphysiofundal height and abdominal girth at the level of the umbilicus, both parameters measured in centimeters.[13] The clinical estimation was carried out to the nearest centimeter using a two surfaced nonstretchable tape; one surface was graduated in centimeters while the other was in inches. The symphysiofundal height was measured from the highest point on the uterine fundus to the midpoint of the upper border of the symphysis pubis using the reverse side (inch surface) of the tape so as to minimize measurement bias. Thereafter, the abdominal circumference was measured immediately at the level of the umbilicus. The fetal weight in grams was then calculated as described above.

After the clinical fetal weight estimation, an abdominal ultrasound scanning was carried out on the participant by a radiology specialist, blinded to the estimated clinical fetal weight. Ultrasound fetal weight was estimated with Hadlock formula using a combination of the biparietal diameter (BPD), abdominal circumference (AC), and femoral length (FL) in estimating the fetal weight.[14] After delivery, the actual birth weight of each participant's neonate was measured within 30 min (nearest 0.1 kg) by trained assistants (midwives) using a standardized neonatal weighing scale.

All data collected from the study were recorded on the 'case record forms' designed for the study and thereafter keyed into the Statistical Package for Social Sciences (SPSS) computer software version 16.0 for windows. Data analysis was adapted from the study from Ile-Ife, Nigeria,[2] using the paired Student's *t*-test, the Wilcoxon signed-rank test, and the Chi-square test as appropriate. Accuracy of clinical or sonographic fetal weights versus the actual birth weight were measured using percentage (relative) error, the absolute percentage error, and the ratio by percentage of estimate within 10% of actual birth weight.

Term pregnancy was defined as the period of gestation from 37 completed weeks up to and including 41 completed weeks and 6 days.[15]

Percentage (relative) error was defined as: Estimated fetal weight (EFW) - actual birth weight (ABW)) × 100/ABW, and absolute error as (absolute value (EFW - ABW)) × 100/ABW.[2] The mean percentage error represented the sum of the positive (overestimation) and negative (underestimation) estimation from actual birth weight, and the mean absolute percentage error was the sum of the absolute deviation (regardless of their direction) reflecting the size of the overall predictive error in terms of actual birth weight.[2] These error terms as well as the ratio by percentage of estimate within 10% of actual birth weight were each the average for each method of estimation of fetal weight in the entire study sample and in the three categories of birth weights.

Results

Two hundred and eleven women were recruited for the study, but only 200 completed the study which gave a completion rate of 94.8%. The mean maternal age was 29.9 ± 3.8 year (range 22-37). The median parity was 1 (range: 0-7). Majority (50.5%, 101/200) of the participants were nulliparous, 24 (12.0%) were primiparous, 68 (34.0%) were multiparous, while 7 (3.5%) were grandmultiparous. The mean gestational age was 39.3 ± 1.8 weeks (range: 37-41).

The mean actual birth weight of the neonates was 3.3 ± 0.55 kg (range: 2.2-4.8). Fifteen (7.5%) babies had birth weights of less than 2.5 kg, 161 (80.5%) 2.5-3.9 kg, while 24 (12.0%) weighed 4.0 kg and higher. Actual birth weight had strong positive correlation with both clinical and ultrasound estimated fetal weights (r = 0.71, $P = 0.00$ and r = 0.69, $P = 0.00$, respectively); the scatter diagrams of their relationships are shown in Figures 1 and 2. Generally, the distributions of the mean percentage (%) error for the two test methods showed normal pattern [Figures 3 and 4], while those of absolute percentage (%) error [Figures 5 and 6] were non-normally distributed.

For all participants, both the clinical and ultrasound methods systematically overestimated the actual birth weight as shown by the mean % error [Table 1]. However, the overestimation by clinical method was significantly higher than that of ultrasound method (18.0 vs 5.1%, $P < 0.001$). Similar pattern was also observed for the mean absolute % error [Table 1]. Furthermore, the proportion of the clinical estimated weights that were within 10% of the actual birth weight was significantly lower than that of ultrasound method (35.0 vs 67.5%; $P < 0.001$).

For babies with normal birth weights (2.5-3.9 kg), both ultrasound and clinical methods overestimated the actual birth weights by varying magnitudes [Table 1]. However, ultrasound method error values were significantly lower than clinical method values for both the mean % error (5.4 vs 19.6%; $P < 0.001$) and the mean absolute % error (9.97 vs 20.6%; $P < 0.001$). Likewise, the proportion of estimates within 10% of the actual birth weight for the ultrasound method was significantly greater than that of the clinical method (68.8 vs 28.8%; $P < 0.001$).

Table 1: A comparison between the accuracy of clinical and ultrasound estimated fetal weights

Accuracy and differences between methods of estimation			
Birth weight category	**Clinical**	**Ultrasound**	***P* value**
Overall (%)			
Mean percentage error	18.0±14.35	5.1±12.51	<0.001*
Mean absolute % error	18.8±13.27	10.9±7.97	<0.001†
Estimates within ABW±10	70 (35.0%)	135 (67.5%)	<0.001†
<2.5 kg (%)			
Mean percentage error	17.4±6.94	21.6±6.32	<0.001*
Mean absolute % error	18.4±6.91	26.5±3.47	0.004†
Estimates within ABW±10	5 (33.3%)	0 (0%)	0.014‡
2.5-3.9 kg (%)			
Mean percentage error	19.6±15.28	5.4±11.28	<0.001*
Mean absolute % error	20.6±13.9	9.9±7.68	<0.001†
Estimates within ABW±10	46 (28.8%)	110 (68.8%)	<0.001†
≥4.0 kg (%)			
Mean percentage error	7.94±2.95	-7.01±10.33	<0.001*
Mean absolute % error	7.94±2.95	10.91±2.68	0.026†
Estimates within ABW±10	19 (76%)	25 (100%)	0.009‡

*Pair *t* test; †Wilcoxon signed-rank test; ‡Chi-square test; ABW=Actual birth weight

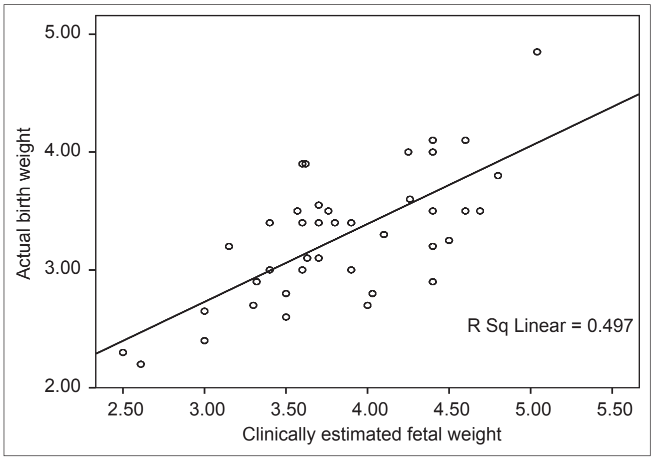

Figure 1: Scatter diagram showing actual birth weight and clinically estimated fetal weight

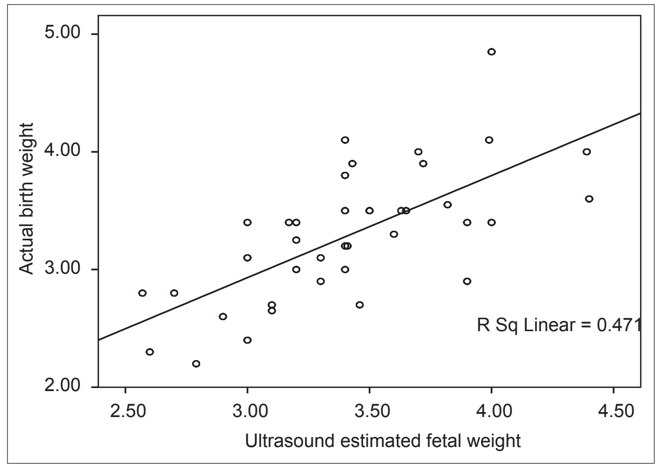

Figure 2: Scatter diagram showing actual birth weight and ultrasound estimated fetal weight

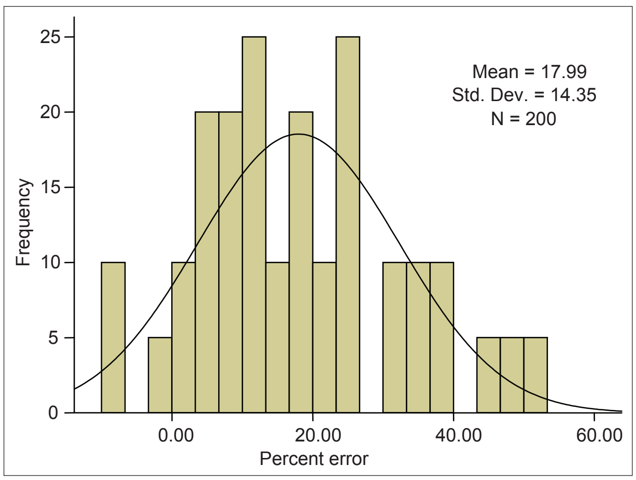

Figure 3: Histogram (distribution) of clinical percentage error

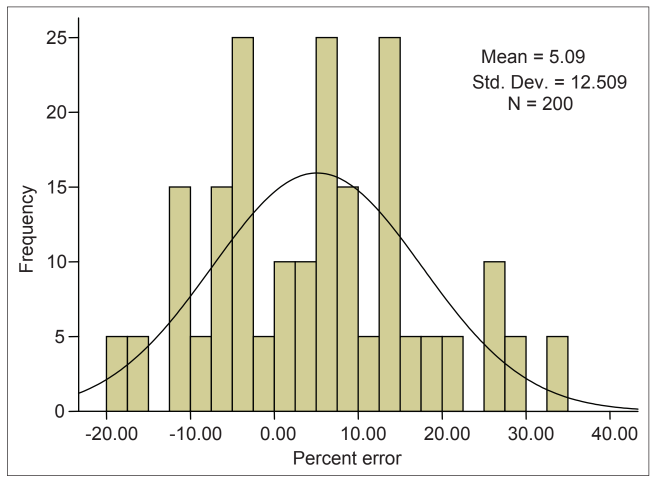

Figure 4: Histogram (distribution) of ultrasound percentage error

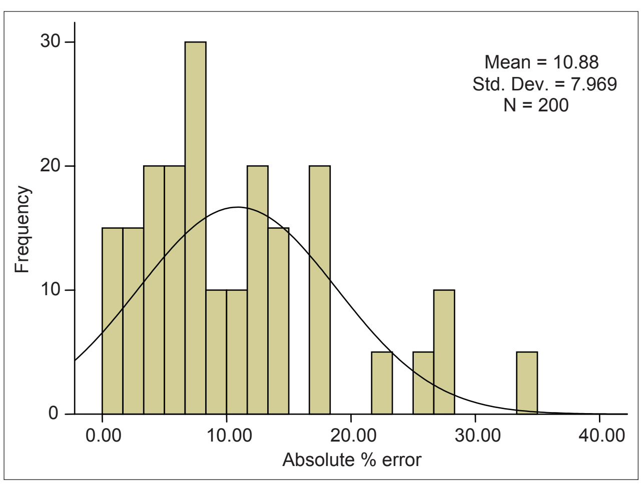

Figure 5: Histogram (distribution) of ultrasound absolute % error

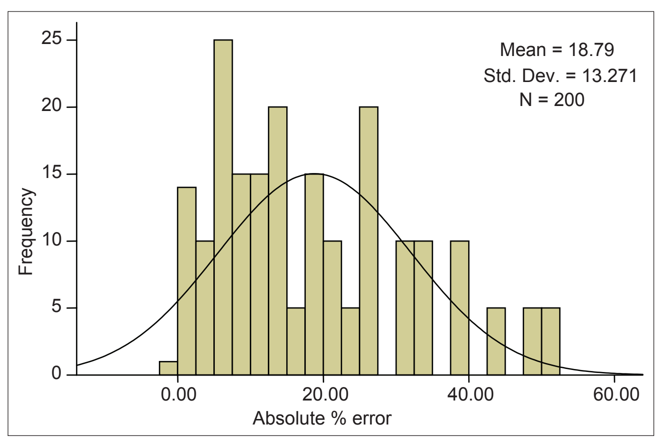

Figure 6: Histogram (distribution) of clinical absolute % error

In macrosomic babies (≥4.0 kg), the mean % error showed that the clinical method systematically overestimated the actual birth weight; while the ultrasound method underestimated it [Table 1]. However, both the mean absolute % error and proportion of estimates within 10% of the actual birth weight for the clinical method were significantly lower than those of the ultrasound method ($P \leq 0.001$). Details are shown in Table 1.

Furthermore, both methods of birth weight estimation overestimated the actual birth weight within low birth weight category (<2.5 kg); the mean % error for clinical method was 17.4 ± 6.94%, while that of the ultrasound method was 21.6 ± 6.32%. The observed difference was statistically significant ($P < 0.001$). Likewise, values of other error measures for clinical method were significantly lower than those of the ultrasound method ($P < 0.001$). Details are shown in Table 1.

Discussion

Overall, both the mean percentage error and the absolute percentage error for ultrasound method were lower than those of the clinical method. This suggests that the ultrasound method of fetal weight estimation is generally more accurate than the clinical method of fetal weight estimation. This study result is similar to the findings by Chauhan and coworkers.[16] Therefore, the ultrasound method, whenever available, should be recommended for accurate fetal weight estimation.

In contrast to the reports of Sherman and coworkers,[17] which showed that ultrasound method has lower absolute error and greater estimates within 10% of actual birth weight than the clinical method in the low birth weight category, this study showed a reversed trend [Table 1]. This interesting finding may imply that in clinical situations where low birth weight is suspected such as severe preeclampsia, severe oligohydramnous, or intrauterine growth restriction; the clinical estimation of the fetal weight may be more accurate than ultrasound fetal weight estimation. Nevertheless, considering the small proportion of low birth weight babies in this study, this finding should be interpreted with caution. Interestingly, another related study, concluded that there was no significant difference in accuracy between the clinical and ultrasound methods for low birth weight babies.[9] In view of these discrepancies, further studies with larger sample of low birth weight babies are necessary.

Furthermore, considering the higher % errors and smaller estimate within 10% of actual birth weight of ultrasound method observed in this study for normal weight babies (2.5-3.9 kg), the ultrasound method may seem to be more accurate than clinical method for this weight category. This finding is supported by the report of a related study,[16] but differed from the findings of Raman and coworkers.[18] On the other hand, other related studies[2,19] did not observe significant difference between the two methods for the estimation of birth weights within the normal range.

As in the study by Shittu and coworkers,[2] this study found that clinical method overestimated the actual birth weight of macrosomic babies (≥4.0 kg), while the ultrasound method underestimated it. However, two other related studies did not find significant difference between the two methods in predicting macrosomic babies.[18,20] Also, the estimates within 10% of actual birth weight was 100% in the ultrasound method as against 76% in the clinical method suggesting that the ultrasound method is a better predictor of fetal macrosomia. Furthermore, the observation that clinical method overestimated birth weight in macrosomic babies may be advantageous clinically as such finding may compel attending physicians or midwives to seek for ultrasound confirmation of fetal weight wherever accessible so as to guide the decision on the preferred route of delivery of the suspected macrosomic baby.

The limitations of this study include the use of only one sonographic model for the ultrasound estimation of the fetal weight and the subjectivity of clinical estimation of fetal weight; however, the rigorous quality measures employed in the study's method would have reduced their effects. Also, each of the two % error measures used in this study has its limitations, but their combination with the proportion of estimates within 10% of the birth weight in this study would have strengthened the study findings–this is because the latter measure appears to be the most appropriate and consistent measure of accuracy.[21]

Using the estimates within 10% of the actual birth weight, it is concluded that overall, ultrasound fetal weight estimation, using Hadlock formula, has higher accuracy than the clinical estimation. This higher accuracy of ultrasound method was also observed within the normal and macrosomic birth weight categories. It is therefore recommended that the ultrasound method should be used in estimating the actual birth weight whenever accessible. However, the clinical method should remain a valuable alternative where ultrasound is unavailable as it also has strong correlation with the actual birth weight.

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