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Original Research Article

Sonographic estimation of foetal weight versus actual birth weight at term

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ABSTRACT

Background: Estimated foetal weight is very critical to decision making in the management of pregnant women. It is therefore important to evaluate the accuracy of ultrasound estimated foetal weight (USEFW) at term in our environment. We compared ultrasound estimated foetal weight at term with the actual foetal birth weight at delivery.
Methods: This was a prospective, comparative cross-sectional study at the Lagos State University Teaching Hospital over a 6-month period. Four hundred and five pregnant women with normal singleton pregnancy, who had sonographic estimation of foetal weight at term, using the Hadlock IV formula, were followed up and had their actual birth weight (ABW) determined at delivery. Accuracy was determined by proportion of estimates within 10% of actual birth weight and mean absolute percentage error (MAPE). The $p<0.05$ was considered significant at 95% confidence interval.
Results: The prevalence of macrosomia was 10.3%. At 10% margin of error, ultrasound accurately estimated the weights of 73.3% of babies. The mean USEFW was 3559.89±316.9g and mean ABW was 3477.42±422.9g with a mean difference of 82.44g ($p<0.001$) and MAPE of 7.11. There was positive correlation ($r=0.669$) between the EFW and ABW ($p<0.001$). The USEFW had a sensitivity of 66.7%, specificity of 91.5%, positive predictive value of 47.5% and negative predictive value of 96.0% in predicting macrosomia.
Conclusions: Ultrasound estimation of foetal weight at term is reliably accurate in predicting actual birth weight in south-western Nigeria.

Keywords: Birth-weight, Foetal weight, Ultrasound estimated foetal weight

INTRODUCTION

Assessment of foetal weight is vital in routine antenatal management especially in high risk pregnancies where growth monitoring is of utmost importance.[1] Accurate estimation of term foetal weight can help the obstetrician in decision making regarding the baby's survival outside the uterus.[1] Birth weight remains the principal variable with the most impact on survival of the neonate.[2] Globally an estimated 16% of live born infants have low birth weight, a condition associated with high perinatal morbidity and mortality.[3] An average estimate of perinatal mortality rate in Nigeria is about 130 per 1000.[4,5] Such high rate of perinatal mortality is a major cause of concern as is in other developing countries.[4] Large for gestational age babies are also at increased risk of neonatal complications.[6] Adequate knowledge of the weight of the foetus in-utero is thus of particular importance in the management of pregnancy, labour and delivery, affording the obstetrician and neonatologist ample information and time to anticipate and prevent foetal weight-related maternal and perinatal morbidity and mortality.[3]

The two main methods for predicting foetal birth weight in current obstetrics practice are clinical and ultrasonographic.[6] 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.[1,7] Modern sonographic algorithms that currently exist are generally comparable in terms of overall accuracy in predicting birth weight.[8,9] This study assessed the accuracy of ultrasound estimated foetal weight by comparing ultrasound estimated foetal weight at term with their actual foetal birth weight at delivery, using the Hadlock IV formula.

METHODS

This was a hospital-based, prospective, comparative cross-sectional study in the Lagos State University Teaching Hospital over a 6-month period (September 2017 to February 2018). Four hundred and five consecutively consenting pregnant women with singleton pregnancy between gestational ages of 37 weeks and 42 weeks, with either an ultrasound estimated gestational age before 13 weeks or known last menstrual period, for dating of pregnancy, were recruited for the study. Women with preterm pregnancy, high risk pregnancy, active phase of labour, multiple gestation and foetal congenital anomaly were excluded from the study.

Relevant socio-demographic data were obtained with the aid of a proforma specially designed for the study. All consenting pregnant women had an obstetric ultrasound scan performed within 14 days of the expected date of delivery (40 weeks gestational age) to exclude congenital anomaly, ascertain foetal well-being and determine the estimated foetal weight (EFW) using the Hadlock IV formula. Pregnant women who did not deliver within 14 days of their obstetric ultrasound scan repeated their scan to re-estimate foetal weight. Women initially recruited who remained undelivered at 42 weeks and beyond were exited from the study.

All sonographic foetal biometric examinations in the radiology unit were performed trans-abdominally by experienced consultant radiologist using a 3.5 MHz curvilinear transducer of high-quality ultrasound systems (Mindray Z5; Mindray Bio-Medical Electronics Co. Ltd. Shenzhen). The average estimated foetal weight was calculated using the Hadlock IV formula below incorporated in the ultrasound machine.[10]

$$Log10EFW = 1.335 - 0.0034\,(AC)(FL) + 0.0316(BPD) + 0.0457(AC) + 0.1623(FL)$$

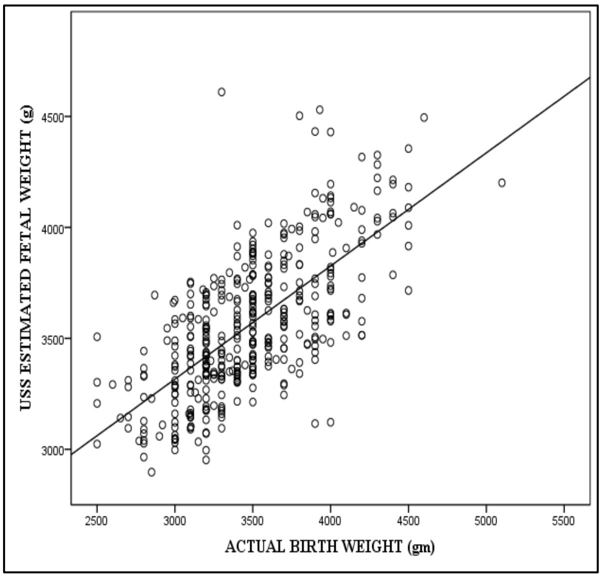
The bi-parietal diameter (BPD) was measured from the proximal echo of the foetal skull to the proximal edge of the deep border (outer-inner) at the level of the cavum septi pellucidi. The head circumference (HC) was measured as an ellipse around the perimeter of the fetal skull.[11] The abdominal circumference (AC) was measured in the transverse plane of the fetal abdomen at the level of the umbilical vein in the anterior third and the stomach bubble in the same plane; measurements are taken around the perimeter.[12] The femur length (FL) was measured in a view in which the full femoral diaphysis was seen and was taken from one end of the diaphysis to the other, not including the distal femoral epiphysis.[13]

At delivery the actual birth weight (ABW) was determined within 30 minutes of delivery using a digital birth weighing scale (SECALENA model 354 by SecaGmBH and co 22089 Hamburg Germany) and recorded to the nearest 10 g.

The data obtained from the study proforma, ultrasound scan EFW and ABW measurements were statistically analysed using Statistical Package for Social Sciences, version 20.0 (SPSS v20.0) Chicago, Illinois. Descriptive statistics were calculated for continuous variables. Percentages and proportions were determined for categorical variables. Student's t-test and chi square were used to compare variables. Measures of accuracy evaluated in the statistical analysis include mean absolute percentage error, and the proportion of estimates within 5% and 10% of actual birth weight. The spearman correlation between the estimated foetal weight and the actual weight was also determined. P-value less than 0.05 was considered to be statistically significant (confidence level = 95%). Ethical approval was obtained from the Health Research and Ethics Committee of the Lagos State University Teaching Hospital.

RESULTS

A total of 405 pregnant women with normal singleton pregnancies at term were recruited and scanned within two weeks of delivery.



Spearman correlation=0.669, p= <0.001*

Figure 1: Scatter plot showing the correlation between actual birth weight and ultrasound estimated foetal weight.

The mean maternal age was 30.98±4.5years, 176 (43.5%) of the women were overweight, 174 (43%) were primigravidae with median IQR of 2 (Q1-Q3=0.0-3.0), 225 (55.6%) had spontaneous vaginal delivery and 52.8% (214) were delivered of male infants (Table 1). The mean gestational age at delivery was 38.48±0.9 weeks (Table 1). None of the babies had low birth weight (<2500 g) at birth and the prevalence of macrosomia (≥4000 g) in the study was 14.6% (Table 1).

Table 1: Socio-demographic and clinical characteristics of the study population.

	Frequency n=405 (%)
Maternal age, years	
≤25	48 (11.9)
26-30	148 (36.5)
31-35	136 (33.6)
≥36	73 (18.0)
	Frequency n=405 (%)
Mean (SD)	30.98±4.5
BMI (kg/m^2)	
Normal	120 (29.6)
Overweight	176 (43.5)
Class I obesity	86 (21.3)
Class II obesity	18 (4.4)
Class III obesity	5 (1.2)
Parity	
None	182 (44.9)
1	113 (27.9)
2	65 (16.1)
≥3	45 (11.1)
Median (IQR)	1.0 (0.0-2.0)
EGA at Birth, weeks	
37	60 (14.8)
38	157(38.8)
39	127 (31.4)
40	54 (13.3)
41	7 (1.7)
Mean±SD	38.48±0.9
Mode of delivery	
Spontaneous vaginal delivery	225 (55.6)
Caesarean section	180 (44.4)
Baby's gender	
Male	214 (2.8)
Female	191 (47.2)
Actual Birth Weight, grammes	
Low birth weight	0 (0.00)
Normal birth weight	363 (89.6)
Macrosomia	42 (10.4)

BMI – Body Mass Index, IQR – Interquartile range, EGA – Estimated gestational age. EFW – Estimated Foetal Weight, Macrosomia – Birth weight > 4kg

Table 2: Comparison of error of estimation of normal weight and macrosomic babies on ultrasound.

	Total N=405 (%)	Normal n= 346 (%)	Macrosomic n=59 (%)	P value*
5% margin of error				
Accurate estimation	183 (45.2)	160 (46.2)0	23 (39.0)	<0.001
Inaccurate estimation	222 (54.8)	186 (53.8)	36 (61.0)	
Underestimation	152 (37.5)	151 (43.7)	1 (1.6)	
Overestimation	70 (17.3)	35 (10.1)	35 (59.3)	

Continued.

	Total N=405 (%)	Normal n= 346 (%)	Macrosomic n=59 (%)	P value*
10% margin of error				
Accurate estimation	297(73.3)	259 (74.9)	38 (64.4)	<0.001
Inacurate estimation	108 (26.7)	87 (25.1)	21 (35.6)	
Underestimation	72 (17.8)	72 (20.8)	0 (0.0)	
Overestimation	36 (8.9)	15(4.3)	21 (35.6)	
Cohen kappa value = 67.2%				

*- Chi square $(X)^2$ applied, n-number of babies, Macrosomic-Babies weighing ≥4kg

Table 3: Comparison of mean ultrasound EFW and ABW.

Parameters	Mean± SD	Range	Mean difference	P value*
Ultrasound EFW	3559.86 ±316.9	2897-4610	82.440	**<0.001**
Actual birth weight	3477.42 ±422.9	2500-5100		**<0.001**
Mean Absolute percentage error = 7.11				

*- Student t-test applied, g-gramme, EFW - Estimated foetal weight, ABW- Actual birth weight

Table 4: Accuracy of ultrasound estimated foetal weight in identifying macrosomic babies.

	Actual birth weight	
	Macrosomic n=42 (%)	**Normal n=363 (%)**
Ultrasound EFW		
Macrosomic n=59 (%)	28 (66.7) (47.5)	31 (8.5) (52.5)
Normal n=346 (%)	14 (33.3) (4.0)	332 (91.5) (96.0)

(%) – Column percentage, [%] – Row percentage, n – number of foetuses/babies. Positive Predictive Value = 47.5%, Negative Predictive Value = 96.0%, Sensitivity = 66.7%, Specificity = 91.5%

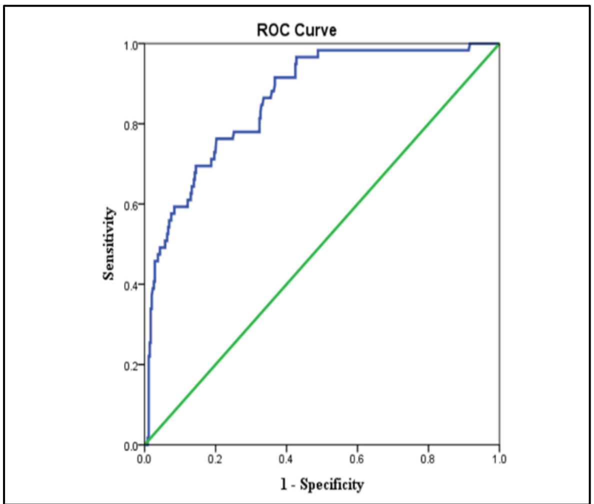


Figure 2: ROC curve showing ultrasound EFW as a predictor of the ABW.

At 10% margin of error, of the total number of babies delivered ultrasound accurately estimated the weights of 297 babies (73.3%), 259 (74.9%) of which were normal weight and 38 (64.4%) were macrosomic (Table 2). No macrosomic baby was underestimated (Table 2). At 5% margin of error, 151 (43.7%) of normal weight babies were underestimated and 35 (59.3%) of macrosomic babies were overestimated (Table 2). When the accuracy of ultrasound at estimating normal weight babies was compared with macrosomic babies, at both 5% and 10% margin of error the differences were statistically significant (p<0.001) (Table 2). Cohen kappa value was 67.2%.

The mean ultrasound estimated foetal weight (USEFW) was 3559.89±316.9g and mean actual birth weight (ABW) was 3477.42±422.9 g (Table 3).

The mean difference between the USEFW and ABW was 82.44 g with a significant p<0.001 and mean absolute percentage error of 7.11 (Table 3). There was positive correlation (r=0.669) between the EFW and ABW (p<0.001) (Figure 1). Figure 2 is a ROC curve showing how reliable ultrasound estimated foetal weight at term is at predicting the actual birth weight. The USEFW had a sensitivity of 66.7%, specificity of 91.5% and positive predictive value of 47.5% and negative predictive value of 96.0% in predicting macrosomia (Table 4).

DISCUSSION

The prevalence of macrosomia at birth in this study was 10.3%. This is similar to the findings of Iyoke et al in Enugu, who reported a prevalence rate of 9.3%, Mai et al in West Algeria of a 10.19% and Ashrafgan et al in Iran of 9.0%.[14-16] It is however higher than reports of Abudu et al in Lagos with a prevalence of 4.9%, Kanamu et al in Aba with 2.5% and Abena et al in Cameroun with prevalence of 6.41%.[17-19] These may largely be due to the different socio-economic circumstances of the participants and variation in study protocols as only normal pregnant women were recruited in our study.

The mean gestational age of delivery in this study was 38.48weeks; this is similar to 38.6 weeks reported by Shittu et al in Ile-Ife.[8] It is however different from the findings of 35.8 weeks by Yau et al in Hong Kong and 37.3 weeks by Predanic et al in New York in related studies.[20,21] These differences may be due to inclusion of preterm infants in these studies by Yau et al and Predanic et al.

The accuracy within 5% and 10% margin of error in this study was 45.2% and 73.3% respectively. This is comparable to the findings of Shittu et al in Ile-Ife, who reported 69% (10% degree of accuracy) and Njoku et al in Calabar, who reported 72% within 10% of ABW, Predanic et al in New York, with 40.3% and 73.6% within 5 and 10% of ABW respectively, Colman et al in New Zealand, with 75% within 10% of ABW, Benaceraf et al in Boston, with 42% and 74% within 5 and 10% of ABW respectively.[8,21-24] It is however lower than the findings of Harlev et al in Israel, with 76% within 10% of ABW, Yau et al in Hong Kong, with 79.3% within 10% of ABW and higher than those of Bajracharya et al in Kathmandu, with 60% within 10% of ABW, Japarath et al in Thailand, with 65.3% within 10% of ABW and Bakshi et al in Dhaka, with 57.3% within 10% of ABW.[20,2528] These variations may reflect population differences as well as inter-observer differences associated with varying degrees of proficiency by sonologists used in the various studies.

In our study the mean USEFW was 3.559.87 g, mean ABW was 3477.42 g and the mean difference was 82.440 g ($p<0.001$). This difference is probably explained by the fact that measurements are based on a formula that use two or more variables and assumes a uniform relationship between two dimensional areas derived from those diameters and volume which is then translated into weight.[29] This uniform relationship may not actually exist because foetuses are not perfectly globular structures.[29] Secondly, the weights of foetuses in the study were not estimated during labour or immediately prior to caesarean delivery. The mean absolute percentage error (MAPE) in our study is 7.11%. This is similar to that of Colman et al in New Zealand, with a MAPE of 7.0 and better than those of Shittu et al in Ile-Ife, with a MAPE of 9.9% and Njoku et al in Calabar, with a MAPE of 9.04%.[8,22,23] It is however higher than that of Yau et al in Hong Kong, with a MAPE of 5.89%.[20] This result is however consistent with what has been previously published that the MAPE for ultrasound estimated foetal weight varies between 6-12% of ABW.[27] Ultrasound estimated foetal weight had good positive correlation with the actual birth weight.

Our study revealed sensitivity and specificity of USEFW, using Hadlock IV formula, in identifying macrosomic babies as 66.7% and 91.5% respectively. This is similar to the findings of Njoku et al with sensitivity and specificity of 69.4% and 92.7%, Benaceraf et al in Boston, with 65% and 90% and Sekor et al in Brisbane, with 60% and 95.6% respectively.[22,24,30] It is however different from the findings of Yao et al in Chinese Han population, with 48.1% and 97.1%, Noumi et al in Brooklyn, with 50 and 97% respectively with better specificity. These differences may be related to the different sonographers used in the studies.[31,32]

CONCLUSION

Ultrasound estimation of foetal weight at term is reliable in predicting actual birth weight in south-western Nigeria.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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