CORRELATION BETWEEN ULTRASOUND ESTIMATED FETAL WEIGHT IN TERM PREGNANCY AND ACTUAL BIRTH WEIGHT AMONGST PREGNANT WOMEN IN JOS

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Abstracts

Background: *High rate of perinatal mortality is still a major cause for concern in developing countries such as Nigeria. A large portion of this problem is related to birth-weight which remains the single most important parameter that determines neonatal survival. A simple and accurate method of estimating intrauterine fetal weight that can be easily applied to all pregnancies is thus an important means of reducing perinatal mortality and morbidity.*

Objective: *To determine the correlation between ultrasound estimated fetal weight in term pregnancy and actual birth weight amongst pregnant women in Jos, North-Central Nigeria*

Methods: *This research was a prospective cross-sectional hospital based study correlating sonographic estimated fetal weight at term with actual birth weight in Jos, North-Central Nigeria. **U**ltrasound estimated fetal weight was calculated using a combination of the biparietal diameter (BPD), abdominal circumference (AC), and femoral length (FL) usingHadlock formula, inbuilt in ALOKA SSD-4000 ultrasound machine fitted with 3.5MHz curvilinear transducer**.***

Results: *A total of 400 women were recruited for the study. The mean maternal age was 29.35 years, and the mean gestational age at delivery was 38 weeks and 6 days. The mean actual birth weight was 3209.31 ± 497.52g while the mean ultrasound estimated fetal weight was 3177.85 ± 533.01g.There was an overall strong correlation between ultrasound estimated fetal weight and actual birth weight (r=0.835) and the difference was not statistically significant (p>0.001.). Also, 75% of the estimates were within 10% of the actual birth weight.*

CONCLUSION: *Ultrasound estimated fetal weight correlated strongly with actual birth weight especially for babies with normal birth weight. However, for babies at the extremes of birth weight, ultrasound estimated fetal weight would need to be correlated with physical examination (including clinical estimation) to avoid unnecessary obstetric intervention.*

KEYWORDS: *Correlation, ultrasound, fetal weight, actual weight, term pregnancy*

INTRODUCTION

Accurate estimation of fetal weight is of paramount importance in the management of labour and delivery. In the last decade, estimated fetal weight has been incorporated into the standard routine ante partum evaluation of high-risk pregnancies and deliveries. In instances like diabetes in pregnancy, vaginal birth after a previous caesarean section, and breech presentation, estimation of fetal weightwill greatly influence their management[1]. Also, when dealing with anticipated preterm delivery, perinatal counselling on likelihood of survival, the intervention undertaken to postpone preterm delivery, optimal route of delivery, or the level of hospital where delivery should occur may be based wholly or in part on the estimation of expected birth weight. Categorization of fetal weight into either small or large for gestational age may lead to timed obstetric interventions that collectively represent significant departure from routine antenatal care[2,3].

High rate of perinatal mortality (39-130 per 1,000 births) is still a major cause for concern in developing countries such as Nigeria[4]. A large portion of this problem is related to birth-weight which remains the single most important parameter that determines neonatal survival[5]. Hence, simple and accurate method of estimating intrauterine fetal weight that can be easily applied to all pregnancies is an important means of reducing perinatal mortality and morbidity. Birth weight is a composite of fetal growth and length of gestation, each of which has different contributions and different sequelae. Removing the contribution of gestational age, birth weight remains the single most important parameter that determines neonatal survival[6].

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. It is estimated that 16% of live born infants have low birth weight, a condition associated with high perinatal morbidity and mortality. On the other hand, fetalmacrosomia is associated with maternal morbidity, shoulder dystocia, birth asphyxia, and birth trauma[7]. It has been suggested that accurate estimation of fetal weight would help in successful management of labour and care of the newborn in the neonatal period and help avoid the complications associated with fetalmacrosomia and low birth weight babies, thereby decreasing perinatal morbidity and mortality[8]. To assess the risk of macrosomia, other known risk factors such as diabetes, should also be taken into account. To determine the mode of delivery, clinical assessment of pelvic capacity should be added to the clinical and sonographicfetal weight estimation, with consideration of the risk factors for macrosomia[9].

Several requests by the Obstetricians to the Radiology Department are seen on every antenatal clinic day in Jos University Teaching Hospital, for estimation of fetal weight. This is known to guide in planning delivery. Consultation is also seen for estimation of fetal weight in a patient in labour in the labour room. This also helps in decision making on the mode of delivery. Establishing the exact correlation between ultrasound estimation of fetal weight and actual birth weight would help enhance decision making and the margin of error would help predict possible unwanted complications that may arise within the extremes of this error margin . It is this anticipated positive contribution that prompted the desire to conduct this study in Jos, North-Central Nigeria.

MATERIALS AND METHODS:

Women with singleton term pregnancy in early labour, or booked for labour induction, or elective caesarean section had ultrasound estimation of fetal weight using a combination of the biparietal diameter (BPD), abdominal circumference (AC), and femoral length (FL) i.eHadlock formula[10] inbuilt in the ALOKA SSD-4000 ultrasound machine fitted with 3.5MHz curvilinear transducer machine.

Before the examination, informed consent was obtained from the patients. Thereafter, the patients were asked to lie on their back on the examination couch. A gel was applied to the anterior abdomen and a transducer from the ultrasound machine was moved gently over the abdomen to enable the visualization of the fetal body parts.

The biparietal diameter, abdominal circumference and femoral length were then measured by the reseacher. The biparietal diameter (BPD) was measured at the level of both thalami and cavum septum pellucidum, from inner to outer table of the skull bones. Abdominal circumference (AC) was measured at the level of the bifurcation of the hepatic vein and gastric bubble. The abdominal imaging plane was a true transverse cut at the level of the fetal liver and stomach, including the left portal vein, at the umbilical region and ensuring that the aorta and IVC are circular. Femoral length (FL) was determined with the femur along the vertical axis seen transversely excluding the femoral head and epiphysis. The transducer was rotated until the longest possible image of the bone was achieved and both cartilaginous ends seen as blunt ends with a strong acoustic shadow posterior to the shaft. These measurements were taken in the appropriate, well-described fashion[11].

After delivery, the actual birth weight of each participant's neonate was measured within 30 minutes by trained assistants (midwives) at the labour ward using a desktop baby scale weighing machine and the weight recorded to the nearest 10g. The actual birth weight obtained was then compared with ultrasound estimated fetal weight by the researcher.

Only neonates delivered within 72hrs of ultrasonic fetal weight estimation were used for this study. This is to ensure that the fetus does not add significant weight between the period of ultrasound fetal weight estimation and time of delivery. Calibration of the weighing scale was done each day to avoid zero error.

STUDY AREA: The study was carried out in the Department of Radiology, Jos University Teaching Hospital (JUTH), a tertiary health institution situated in the central part of Jos.

STUDY POPULATION: All pregnant women at term that came for antenatal clinic or are admitted into the maternity ward for elective delivery via induction of labour or caesarian section during the study period

STUDY DESIGN: This was a hospital based prospective cross-sectional study that spanned from march to september 2015 with additional samples taken between October and December 2016. Subjects were recruited based on the inclusion criteria stated below until the sample size was reached.

SAMPLE SIZE ESTIMATION

The sample size was calculated using the formula for cross-sectional studies as shown[12];

$$\textbf{Sample size (n)} = \frac{P(1-P)Z^2}{d^2}$$

$$\text{Therefore, } \mathbf{n} = \frac{0.50(0.50)\ 3.8416}{0.0025}$$

n= 384.2

The sample size **n,** was then estimated to 400.

INCLUSION CRITERIA

1. Singleton pregnancies at term with intact membrane
2. Women being prepared for elective caeserean section or in early labour

EXCLUSION CRITERIA

1. Multiple gestations
2. Intrauterine fetal demise
3. Congenital anomalies (detected on ultrasound)
4. Unstable patients such as eclamptics
5. Delivery after 72hrs of ultrasonic fetal weight estimation
6. Severe medical conditions complicating pregnancy such as hypertensive disorders, HIV/AIDS, and sickle cell anaemia

ETHICAL CONSIDERATION: The study protocol was approved by the Research and Ethical Committee of Jos University Teaching Hospital.

STATISTICAL ANALYSIS: Computerized data base was obtained which was subsequently analysed and processed using SPSS software version 23.

RESULTS

A total of 400 pregnant women at term pregnancy were recruited for the study which lasted over a period of about 8 months. The mean maternal age was 29.35 years, and the mean gestational age at delivery was 38 weeks and 6 days. The maternal age range was 18 - 45 years. The mean actual birth weight was 3209.31 ± 497.52g while the mean ultrasound estimated fetal weight was 3177.85 ± 533.01g (Table1).

A total of 34 (8.5%) of the babies actually weighed less than 2500g while 38 (9.5 %) weighed ≥4000g as against 36 (9%) and 37(9.3%) respectively for sonographic weight estimation. Also, three hundred and twenty-eight (82.0%) actually weighed between 2500g and <4000g as against 327 (81.8%) on ultrasonography (Tables 2a and 3). Ultrasound estimated fetal weight correlated strongly with the actual birth weight with a linear relationship (Figure1).

The mean error in estimating large birth weight was 266.58±126.64g and low birth weight was 161.91 ±127.33g with an absolute error of 245.73±175.51g at 95% Confidence Interval (Table 4).

The overall mean absolute percentage error was 7.48 ± 5.35, and the percentage of estimate within 10% of actual birth weight (ABW) was 75.0%. The observed difference was not statistically significant ($p \geq 0.446$) with a correlation coefficient $r \geq 0.835$. However, a weak positive correlation with statistically insignificant difference was observed for both low birth weight ($r \geq 0.180$, $p \geq 0.309$), and high birth weight babies ($r \geq 0.155$, $p \geq 0.353$).Strong positive correlation ($r \geq 0.711$) exist in fetal weight estimation between 2500 - <4000g (Table5, Figure 2).

Table 1: Maternal and infant demographics

Characteristics	Mean ±SD
Maternal age (years)	29.35 ± 5.55
Gestational age at delivery (weeks)	38.91 ± 1.12
Actual birth weight (g)	3209.31 ± 497.52
USS weight (g)	3177.85 ± 533.01

Table 2a: Relationship between USS estimated fetal weight and actual birth weight

		Actual birth weight (g)			
		<2500	**2500-<4000**	≥4000	**Total**
USS estimated fetal weight (g)	**<2500**	25(6.3)	11(2.8)	0(0.0)	36(9.0)
	2500-<4000	9(2.3)	308(77.0)	10(2.5)	327(81.8)
	≥4000	0(0.0)	9(2.3)	28(7.0)	37(9.3)
	Total	34(8.5)	328(82.0)	38(9.5)	400(100.0)

Table 2b: Pearson's correlation coefficient

		USS EFW (g)	**Actual fetal weight**
USS EFW	Pearson Correlation	1	0.835**
	P		0.000
	N	400	400
Actual fetal weight	Pearson Correlation	0.835**	1
	P	0.000	
	N	400	400

**. Correlation is significant at the 0.05 level

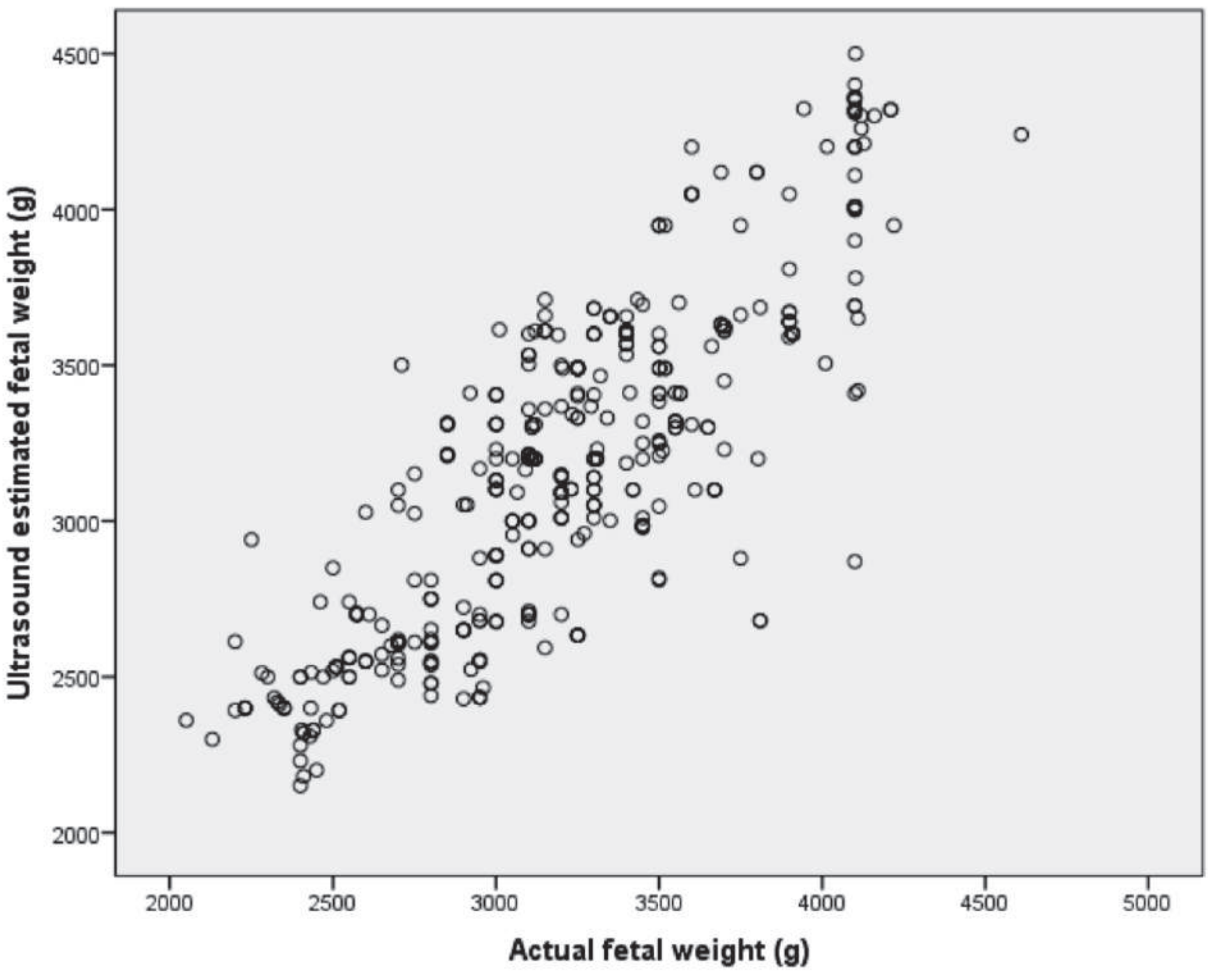

Figure 1: Scatter diagram showing the relationship between ultrasound estimated fetal weight (USS EFW) and actual birth weight (ABW)

Table 3: Relationship between the total number of sonographically predicted birth weight and actual birth weight

Birth weight classification	**Method**		χ^2	**P**
	Sonographic (%)	**Actual (%)**		
Low (<2500g)	36(51.4)	34(48.6)	0.057	0.811
Normal (2500-<4000g)	327(49.9)	328(50.1)	0.002	0.969
Macrosomia (≥ 4 0g) 0	37(49.3)	38(50.7)	0.013	0.908

Table 4: Mean error in birth weight prediction

Characteristics	Mean (g)	95% Confidence Interval (C. I.)
≥4000 g	266.58 ± 201.37	238.91 - 312.31
<2500 g	161.91 ± 127.33	244.13 - 297.22
Absolute error	245.73 ± 17551	167.47 - 929.48

Table 5: Accuracy and percentage difference between actual birth weight and USS EFW

Birth - weight stratum	USS EFW Mean ± SD	P value
Overall		
Mean percentage error	0.73 ± 9.18	
Mean absolute percentage error	7.48 ± 5.35	
Estimate within ABW ±10%	75.0%	
Pearson's correlation coefficient	0.835	0.446
<2,500g		
Mean percentage error	2.73 ± 8.72	
Mean absolute percentage error	7.02 ± 5.74	
Estimate within ABW ±10%	79.4%	
Pearson's correlation coefficient	0.180	0.309
2,500 - <4,000g		
Mean percentage error	1.03 ± 9.25	
Mean absolute percentage error	7.64 ± 5.29	
Estimate within ABW ±10%	240 (73.2%)	
Pearson's correlation coefficient	0.711	0.435
≥4,000 g		
Mean percentage error	1.21 ± 8.48	
Mean absolute percentage error	6.47 ± 5.52	
Estimate within ABW ±10%	86.8%	
Pearson's correlation coefficient	0.155	0.353

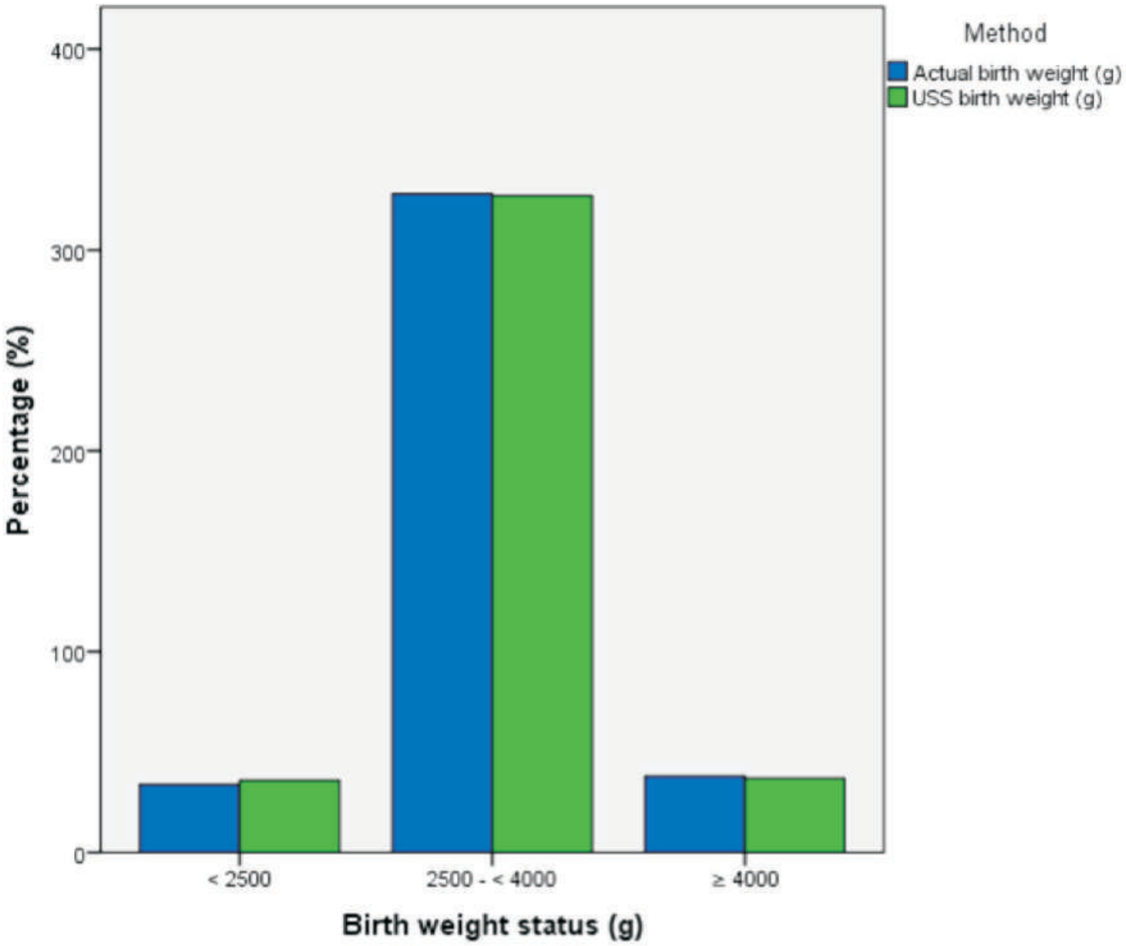

Figure 2: Bar chart of proportion of birth weight group as determined by USS and actual birth weight

DISCUSSION

Nigeria, and indeed, most countries in the sub-Saharan African region are currently having the world's worst maternal and infant mortality rates[13]. Prediction of pre-natal fetal weight is part of standard antenatal care which helps to reduce maternal risks associated with pregnancy such as prolonged labour, pelvic injuries, postpartum bleeding and pre- and peri-natal fetal risks such as shoulder dystocia and birth asphyxia[7].The tendency of ultrasound estimation of fetal weight to err towards normal when the infant was subsequently found to be either <2500 g or >4000 g is important because the estimation of fetal weight at these extremes is of relevance in clinical decision-making[15].

Accuracy of ultrasound estimated fetal weight was determined using absolute percentage error and weight within 10% of the actual birth weight (ABW). Themean absolute percentage error reflects the variability noted regardless of their direction and as such, is a much more accurate predictor of differences from actual birth weight than the mean percentage error[14]. Hence, the variation between predicted birth weight and actual birth weight was expressed in the form of mean absolute percentage error in this study. Overall, the correlation coefficient between ultrasound estimated fetal weight (USSEFW) and actual birth weight was +0.835, with mean percentage error of 0.73± 9.18, and mean absolute percentage error was 7.48± 5.33 and the difference was not statistically significant ($p \geq 0.446$).

Determination of weight within 10% of actual birth weight is considered acceptable accuracy[5]. In this study, 75.0% of fetal weight estimations were within 10% of actual birth weight. Although the accuracy of our estimations was comparatively good, one in fourfetal weight estimations was more than 10% different from the actual birth weight.This is consistent with findings of Eze*et a1*[19] in lagos Nigeria, and Benacerraf *et al*[16] in Boston, who also obtained 75% of estimates within 10% of ABW.This finding is comparatively similar to that obtained by

Ugwu*et al*[17] in South-East Nigeria which shows 67.5% of estimates to be within 10% of ABW,andShittu*et al*[18]who obtained 68.0% in South-West. The findings may be attributed to the accuracy of USS in estimating birth weight at term in the studied population.

The mean actual birth weight in this study was 3209.31 ± 497.52g. This was similar to the mean actual birth weight of 3254 ± 622g reported by Shittu*et al*[20]in Ife, Nigeria, and 3080 ± 0.610 g by Swende[19] in Makurdi, Nigeria.However, it is significantly lower than 3,568 ± 496g documented in United Kingdom. This finding supports the report in literature which had suggested that birth weight of African babies is generally smaller than that of Caucasian babies[20]. The cause of the differences noted was not investigated in the study. However, technical limitations such as resolution power of our scanner and observer errors in measurements may have contributed. Socioeconomic status as well as racial differences may also have contributed as previously reported by Hadlock*etal*[21].

Ultrasound (USS) underestimated the low birth weights in 11 (30.6%) cases. That is, the proportion of low birth weights that were accurately estimated was 69.4% with **79.4%** of the cases within 10% of the ABW. However, a weak positive correlation exists between USS estimated fetal weight and the ABW and the difference was not statistically significant ($r \geq 0.18$, $p \geq 0.309$). A similar finding was reported by Shittu*etal*[18] in Ile Ife, Nigeria, who found out that ultrasound underestimated the low birth weights in only 33.3% of cases. Ugwu*et al*[17] obtained a lower value of 5.1%. The difference here may be due to the high operator dependence of the procedure.Moreover, there was no statistically significant difference ($p \geq 0.811$)in the number of sonographically predicted low birth weight fetuses and the actual number born with low birth weight.

The accuracy of the ultrasound estimation in this study was highest in birth weight range of 2500 - <4000g where 308(77%) of the fetuses fall within. Ultrasound underestimated the actual birth weight in only 10 (3.0%) cases and overestimated it in 9 (2.7%) cases. About 81.8% of cases were accurately estimated as normal birth weight. The correlation between USS estimated fetal weight and actual birth weight was +0.711 and the difference was not statistically significant ($p \geq 0.446$). This is similar to that obtained by Ugwu*et al*[17] who found out that babies with normal birth weights (2500 - <4000g) had significantly lower percentage error when compared with the clinical method, and showed positive correlation. A total of 361 (90.3%) of the fetuses were accurately estimated as low, normal or high birth weight.

Furthermore, ultrasound underestimated large birth weights in 24.3% of cases. This again means that the proportion of large birth weights (fetalmacrosomia) that were accurately estimated is 75.7% with 86.8% within 10% of the ABW. A weak positive correlation coefficient was obtained ($r \geq 0.155$) and the difference was not statistically significant ($p \geq 0.353$). Also, no significant difference was found ($p \geq 0.908$) in the number of sonographically predicted macrosomia and the actual number of macrosomic babies. A similar finding was also obtained by Eze*et al*[22] in Southwest Nigeria,where he found out that there was no statistically significant difference in the number of ultrasound EFW and ABW ($p>0.05$).

The study have shown that overall, ultrasound slightly underestimated both low birth weight and high birth weight babies with a positive correlation between the estimated and actual birth weight, and the difference was not statistically significant ($p>0.05$). Similar findings were also obtained by Kurmanavicius*et al*[23] who showed that USS tend to underestimate both low and high birth weight babies.

The relationship between birth weight and the direction of the estimation error was not due to a bias in the time interval between ultrasound and delivery as there was no significant relationship between infant birth weight and the time interval between ultrasound and delivery here. In this study, the ultrasound estimations were performed at most 3 days prior to delivery. This was similar to studies done elsewhere[17]. Although some authors studying reliability of ultrasound estimation of fetal weight have included estimations performed up to 14 days prior to delivery[17], others have restricted their data to estimations performed within 7 days for example Nzeh*et al*[25], or have attempted to correct for the time elapsed between the ultrasound and delivery by the addition of 25 -30g per day. These estimates were avoided in this study.

CONCLUSION

Ultrasound estimated fetal weight correlated strongly with actual birth weight. This implies that a high level of agreement exists between estimated fetal weight and actual birth weight. It can therefore be assumed that sonographically estimated fetal weight appear to have truly predicted actual birth weights in the studied population. We also need to keep in mind that ultrasound measurements are operator dependent. Hence, care should be taken to ensure that sonologists with atleast minimum training, are involved in ultrasound measurements of fetal weight especially at theextremes of fetal birth weight.

References

1. Sherman DJ, Arieli S, Tovbin J, Siegel G, Caspi E, Bukovsky IA. Comparison of clinical and ultrasonic estimation of fetal weight. *Obstet Gynecol*. Feb 1998;9:212-7.
2. Nzeh DA, Oyawoye O, Adetoro O. Ultrasound estimation of birth weight in late pregnancy among African women. *West Afr J Med.* 2000;1:9–14.
3. Hendrix NW, Grady CS, Chauhan SP. Clinical versus sonographic estimates of birth weight in term of parturients. A randomized clinical trial. *J Reprod Med*. 2000;45:317-22.
4. DiejomaohFME.Perinatal and maternal mortality. *In*: Agboola A, editor. Textbook of obstetrics and gynaecology for medical student,. Lagos: University Services Educational Publishers, 1988;2:304-14.
5. Watson WJ, Soisson AP, Harlass FE. Estimated weight of the term foetus. Accuracy of ultrasound vs. clinical examination. *J Reprod Med* 1988;33:369-71.
6. Mavalankar DV, Trived CR, Gray RH. Levels and risk factors for prenatal mortality in Ahmadabad, India. *Bull World Health Organ.* 1991;69:35–42.
7. Nahum G, Stanislaw H. Ultrasonographic prediction of term birth weight: how accurate is it? *Am J ObstetGynecol* 2003;188:566–574.
8. Chauhan SP, Hendrix NW, Magann EF, Morrison JC , Devoe LD. Limitations of clinical and sonographic estimates of birth weight: experience with 1034 parturients. *Obstet Gynecol*. 1998;91:72-7.
9. Ben-Haroush A, Yogev Y, Mashiach R, Hod M, Meizner I. Accuracy sonographically estimated fetal weight in 840 women with different pregnancy complications prior to induction of labor. *Ultrasound ObstetGynecol*2004;23:172–176.
10. 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 ObstetGynecol*1985;151:333–337.
11. Chitty LS, Altman DG, Henderson A, Campbell S. Charts of fetal size, 2: head measurements. *Br J ObstetGynaecol* 1994;101:35–43.
12. Araoye MO. Sample size determination In: Araoye (Ed). A research methodology with statistics for health and social sciences.1st Ed. Saw mill publishers, Ilorin, 2003; 115-129
13. Maya Z. Maternal mortality in Nigeria; an indicator of women's status. Available at http;//www.consultancyafrica.com. Accessed on March 18, 2015.
14. Bajracharya J, Shrestha NS, Karki C. Accuracy of Prediction of Birth Weight by Fetal Ultrasound. *Kathmandu Univ med J* 2012;38:74-76.
15. Atalie C, Dushyant M, John H, Jeremy T. Reliability of ultrasound estimation of fetal weight in term singleton pregnancies . *N Z Med J*2006;119:1-8.
16. Benacerraf BR, Gelman R, Frigoletto FD Jr. Sonographically estimated fetal weights: accuracy and limitation. *Am J Obstet Gynecol*. 1988; 159(5):111821.
17. Akinola SS, Oluwafemi KO, Ernest OO, Niyi OM, Solomon OO, *et al.* Clinical versus Sonographic Estimation of Fetal Weight in Southwest Nigeria. *J health populnutri*2007;25(1):14-23
18. 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, SouthEastern Nigeria .*Niger J ClinPract.* 2014:17(3):270-74.
19. T. Z. Swende. "Term birth weight and sex ratio of offspring of a Nigerian obstetric population," *IJBMR* 2011; 2:531–532.
20. Glenn E (ed). Mass of a newborn baby. In: The physics Factbook. Available at http://hypertextbook.com/facts/2002/LeahOppenheim1.shtml. Accessed on June 2, 2016.
21. Hadlock FP, Deter RL, HarristRB,Park SK. "Estimating Fetal age : Computer assisted analysis of multiple fetal growth parameters

JCU 2004;152:297 – 501.
22. Eze CU, Abonyi LC, Njoku J, Okorie U, Owonifari O. Correlation of ultrasonographic estimated fetal weight with actual birth weight in a tertiary hospital in Lagos, Nigeria.*Afri Health Sci*. 2015;15(4):1112-22
23. Cohen, J. M., Hutcheon, J. A., Kramer, M. S., Joseph, K. S., Abenhaim, H. and Platt, R. W. Influence of ultrasound-to-delivery interval and maternal–fetal characteristics on validity of estimated fetal weight. *Ultrasound ObstetGynecol*, 2010;35:434–441.
24. Mehdizadeh A, Alaghehbandan R, Horsan H. Comparison of clinical versus ultrasound estimation of fetal weight. *Am J Perinatol*. 2000;17:233–6.
25. Nzeh DA, Rimmer S, Moore WMO, et al. Prediction of birth weight by fetal ultrasound biometry. *Br J Radiol*1992;66:987-89.