INTRODUCTION

Assessment of fetal weight is a vital and universal part of antenatal care, not only in the management of labor and delivery but often during the management of high risk pregnancies and growth monitoring. Birth weight of an infant is the single most important determinant of newborn survival ***(Ugwu et al., 2014)***.

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. Neonatal complications are more associated with low birth weight ***(Coutinho et al., 2011)*** and labor abnormalities as well as neonatal complications with fetal macrosomia ***(Fuchs et al., 2013)***.

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 (***Olamijulo and Olaleye, 2011)***.

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 ***(Ezegwui et al., 2011)***.

The two main methods for predicting birth weight in current obstetrics are clinical and ultrasonographic methods ***(Westerway, 2012)***.

Clinical method includes models incorporating height of the uterus and girth of the abdomen measured at the level of umbilicus. Estimation of fetal weight is done ultrasonographically using abdominal circumference (AC) alone ***(Campbell and Wilkin, 1975)***, AC and biparietal diameter (BPD) ***(Sheppard et al., 1982)*** and AC, BPD and femur length ***(Hadlock et al., 1984)***.

A study of ***Poushali et al. (2012)*** concluded that fetal thigh circumference has a role to play in accurately measuring fetal weight when incorporated with other fetal parameters, using abdominal circumference, fetal thigh circumference (TC), femur length and biparietal diameter.

Ultrasound method of fetal weight estimation is generally more accurate than the clinical method of fetal weight estimation. Therefore, the ultrasound method, whenever available, should be recommended for accurate fetal weight estimation ***(Ugwu et al., 2014)***.

Increasing attention is being paid to the accuracy of using various ultrasound measurements in estimating fetal weight. Multiple fetal parameters for prediction of fetal weight are employed. These are the biparietal diameter, head circumference, abdominal circumference, and femoral length. Ultrasound estimation of fetal weight, while being accurate to a degree, is associated with error ranging from ±6 to 11% depending on parameters measured and the equation used for estimation ***(Dudley, 2005)***.

Various investigators who have systematically compared the numerous established and more recent weight equations have confirmed that the Hadlock formulae perform equally well and so the new weight equations provide only marginal benefit ***(Hoopmann et al., 2010)***.

Fetal ultrasound using Hadlock's formula has error in estimation of fetal weight by about 290 gm ± 250 gm. In 40% of the cases, there is an error of estimation by more than 10% compared to actual weight ***(Bajracharya et al., 2012)***.

A study of ***Kehl et al. (2012)*** indicates that the current accuracy of fetal weight estimation with conventional biometric parameters by 2D ultrasound has reached its limits. Further improvement will probably only be achieved through new approaches in ultrasonography.

Aim of the Work

The purpose of this study is to evaluate the accuracy of Five-Dimensional (5D) ultrasound fetal biometry compared to Two-Dimensional (2D) ultrasound in prediction of fetal weight among pregnant women. This will help in appropriate decision making in the management of the pregnant woman.

Research Hypothesis

In pregnant women at term, Five-Dimensional Ultrasound (5D-US) fetal biometry may be of the same accuracy in prediction of fetal weight as conventional parameters by Two-Dimensional Ultrasound (2D-US).

Research Question

Does Five-Dimensional Ultrasound (5D-US) fetal biometry have better accuracy in prediction of fetal weight among pregnant women at term?

Prenatal Sonographic Assessment of Fetal Weight

Accurate prediction of fetal weight has been of great interest in obstetrics. As fetal weight cannot be measured directly, it must be estimated from fetal and maternal anatomical characteristics ***(Westerway, 2012).***

Both fetal macrosomia and intrauterine growth restriction increase the risk of perinatal morbidity and mortality and of long-term neurologic and developmental disorders. Identification of intrauterine growth restriction and macrosomia will reduce the chance of fetal morbidity and mortality ***(Westerway, 2012).***

The high perinatal morbidity and mortality associated with low birth weight are attributable to preterm delivery, intrauterine growth restriction, or both. For excessively large fetuses, the potential complications associated with vaginal delivery include shoulder dystocia, brachial plexus injury, bone injuries, and intrapartum asphyxia, while the maternal risks include birth canal and pelvic floor injuries, increased rate of operative vaginal and caesarean deliveries and postpartum hemorrhage ***(Ekele and Otubu, 2006).***

Limiting the potential complications associated with the birth of both small and excessively large fetuses require that accurate estimation of fetal weight occurs before decision to deliver is made ***(Kehinde et al., 2013).***

Tactile assessment of fetal size, also referred to as clinical palpation or Leopold maneuvers, is considered the oldest technique for assessing fetal weight. It involves manual assessment of fetal size by the obstetricians ***(Horta et al., 1997).***

Worldwide, tactile assessment of fetal size is used extensively because it is both convenient and virtually costless; however, it is a subjective method associated with notable predictive errors ***(Saqib et al., 2008).***

When ultrasound is performed with quality and precision, there is evidence to suggest that dating a pregnancy using ultrasound measurements is clinically superior to using menstrual dating with or without ultrasound, and this has been advocated and adopted in other jurisdictions (***Salomon et al., 2013).***

The available techniques for fetal weight estimation can be broadly classified as:

All the currently available methods for assessing fetal weight in utero are subjected to significant predictive errors. These errors are the most clinically relevant at the 2 extremes of birth weight (e.g., those <2500 gm who are also likely the products of premature deliveries and those > 4000 gm who are at risk at risk for the complications associated with fetal macrosomia) ***(Shittu et al., 2007).***

The two main methods for predicting birth weight in current obstetrics are clinical and ultrasonographic methods ***(Westerway, 2012).***

A- <u>Clinical methods:</u>

- Tactile assessment of fetal size, e.g. Leopold's maneuver.
- Clinical risk factor.
- Maternal self-estimated fetal weight.
- Prediction of equations of birth weight.

B- <u>Imaging methods:</u>

- Ultrasound.
- Magnetic resonance imaging.

Tactile assessment of fetal size

Dare et al. used this technique by multiplying the abdominal girth (cm) with symphysio-fundal height (cm) and calculated the estimated fetal weight in grams ***(Dare et al., 1990)***.

This method is less accurate for obese than non-obese and carries a significant intra observer variation. The inherent growth potential of the baby and nutritional status of the mother are concurrently measured. The resultant estimate is closest to the actual birth weight as pointed by several prospective studies ***(Banin et al., 2002).***

Clinical risk Factor

This method involves quantitative assessment of clinical risk factors and has been shown to be valuable in predicting fetal weight ***(Nidhi et al., 2014).***

In case of fetal macrosomia, the presence of risk factors, such as maternal diabetes mellitus, prolonged pregnancy, obesity, pregnancy weight gain of >20 kg, maternal age >35 years, maternal height> 5ft 3 inches, multiparity, male fetal sex and white race ***(Nidhi et al., 2014).***

In low estimated birth weight socioeconomic status, constitutionally small mother, poor maternal weight gain, fetal infections, congenital malformations, chromosomal abnormality, teratogenic exposure, maternal anemia, Anti phospholipid Antibody syndrome and other medical disorders complicating pregnancy should be mentioned ***(Nidhi et al., 2014).***

Maternal Self estimation

In literate society maternal self-estimation of fetal birth weight in multiparous women show comparable accuracy to clinical palpation in some studies for predicting abnormally large fetus ***(Banin et al., 2002).***

Birth weight Prediction equations

Various calculations and formulae based on measuring uterine fundal height above symphysis pubis have been developed ***(Nidhi et al., 2014).***

Ojwang et al. used the product of symphysio-fundal height and abdominal girth measurement at various levels in centimeters above symphysis pubis in obtaining a fairly acceptable predictive value but with considerable variation from the mean ***(Ojwang et al., 1984).***

Dare et al. simplified and used the product of symphysio-fundal height (Mc Donald's measurement) and abdominal girth at the level of umbilicus measured in centimeters and result expressed in grams to estimate fetal weight in uterus at term, and the estimation correlated well with birth weight ***(Dare et al., 1990).***

Johnson's formula for estimation of fetal weight in vertex presentation is as follows Fetal weight (grams) = (Mc Donald's measurement of symphysio-fundal height in cm –X) x 155 where X = 13, when presenting part was not engaged, X = 12 when presenting part is at 0 station and X = 11 when presenting part was at +1 station. If a patient weighs more than 91 kg, 1cm is subtracted from the fundal height ***(Nidhi et al., 2014).***

Dawn's formula states that weight (grams) = longitudinal diameter of the uterus x transverse diameter of the uterus x 1.44/2.Measurements are made with pelvimeter. Double abdominal wall thickness was also measured pelvimeter. If Double abdominal wall thickness was more than 3 cm, the excess was deducted from the longitudinal diameter ***(Nidhi et al., 2014).***

Role of obstetric Ultrasound in fetal weight estimation

Monitoring fetal growth is a standard component of antenatal care. Investigators have developed several equations for estimating fetal weight in the late second and the third trimester. These equations involve a variety of sonographically obtained biometric measurements. The fetal weight derived from these equations is then compared to distributions normalized for gestational age to identify growth outside the norm ***(ACOG, 2013).***

Ultrasound examination typically involves measurement of multiple biometric parameters that are incorporated into a formula for calculating estimated fetal weight (EFW). Most commonly, a combination of biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). The two most popular formulas are Warsof's ***(Warsof et al., 1997)*** with Shepard's modification ***(Shepard et al., 1982)*** and Hadlock's ***(Hadlock et al., 1985)***. These formulas are included in most ultrasound equipment packages. However, at least 30 formulas for estimating fetal weight have been published.

Accuracy of 2D Ultrasound in prediction of fetal weight

During the last 30 years, sonographic assessment of the fetus and estimation of its weight have become part of routine practice in obstetrics. Since the 1970s, biometric parameters such as the biparietal diameter (BPD), fronto-occipital diameter (FOD), head circumference (HC), abdominal transverse diameter (ATD), anterior-posterior abdominal diameter (APD), abdominal circumference (AC), and femur length (FL) have been included in formulae for calculating an estimate of fetal weight. Many formulae have been published, most of them involving combinations of several biometric parameters ***(Siemer et al., 2009).***

Several technical limitations of the sonographic techniques for estimating fetal weight are well-known; among these are maternal obesity, oligohydraminos, and anterior placentation ***(Shittu et al., 2007).***

Other disadvantages of ultrasonography are that it is both complicated and labor intensive, potentially being limited by suboptimal visualization of fetal structure. It is also requires costly sonographic equipment and specially trained personnel, Although such expensive imaging equipment is widely available in developed countries, this is generally not the case in developed nations where medical resources are scarce ***(Shittu et al., 2007).***

Consistent with these beliefs, much effort has generated best-fit fetal biometric algorithms that can make birth weight predictions based on obstetric Ultrasonographic estimation. As such, the Ultrsonographic technique represents the newest and most technologically sophisticated method of obtaining birth weight estimation ***(Raman et al., 2008).***

An accurate means of estimating fetal weight using ultrasonography was first described by Campbell and Wilkin D 1975 ***(Campbell and Wilkin, 1975).*** The advantage of this technique is that it relies on linear and/or planar measurements of in utero fetal dimensions that are definable objectively and are reproducible ***(Asim and Frank, 2004)***.

The sonographic prediction algorithms used to make fetal weight estimations in various studies were those of Shepard's, Hadlock, Sabbagha and Warsof's, in addition to the best of 8 algorithms based on various combinations of abdominal cirumference (AC), femur length (FL), biparietal diameter (BPD), and head circumference (HC), both singly and in combination ***(Campbell et al., 1975, Nzeh et al., 1992, Nzeh et al., 2000, Nahum, 2002, Anderson et al., 2007).***

The most commonly used fetal biometric algorithms are shown in Figure (1) and Table (1):

Authors	Formulae
Hadlock, *et al.* [11]	Log_{10} (Estimated fetal weight) = 1.3598 + 0.051AC + 0.1844FL − 0.0037(FL × AC)
Hadlock, *et al.* [12]	Log_{10} (Estimated fetal weight) = 1.335 − 0.0034(AC × FL + 0.0316BPD + 0.0457AC + 0.1623FL)
Shepard, *et al.* [15]	Log_{10} (Estimated fetal weight) = 1.7492 + 0.166BPD + 0.046AC − 0.00264(AC × BPD)
Nzeh, *et al.* [16] (formula 1)	Log_{10} Birth foetal weight = 0.470 + 0.488 Log_{10} BPD + 0.554 Log_{10} FL + 1.377 Log_{10} AC
Nzeh, *et al.* [16] (formula 2)	Log_{10} (Birth weight) = 0.326 + 0.00451(SDI) + 0.383 Log_{10} BPD + 0.614 Log_{10} FL 1.4885 Log_{10} AC

Figure (1): Different Formulae used for estimation of birth weight by ultrasound ***(Ayoola et al., 2008).***

Table (1): Different ultrasound regression formulae for estimating fetal weight ***(Siemer et al., 2009)***

Regression Formula	Year of Publication	Regression equation
Hadlock (I) (Hadlock FP et al., 1985)	1985	Log10 EFW = 1.3596 – 0.00386 AC × FL + 0.0064 HC + 0.00061 BPD × AC + 0.0424 AC + 0.174 FL
Hadlock (II) (Hadlock FP et al., 1985)	1985	Log10 EFW = 1.304 + 0.05281 AC + 0.1938 FL – 0.004 AC × FL
Hadlock (III) (Hadlock FP et al., 1985)	1985	Log10 EFW = 1.335 – 0.0034 AC × FL + 0.0316 BPD + 0.0457 AC + 0.1623 FL
Hadlock (IV) (Hadlock FP et al., 1985)	1985	Log10 EFW = 1.326 – 0.00326 AC × FL + 0.0107 HC + 0.0438 AC + 0.158 FL
Hadlock V (Hadlock FP et al., 1984)	1984	Log10 EFW = 1.5662 – 0.0108 HC + 0.0468 AC + 0.171 FL + 0.00034 HC2 – 0.003685 AC × FL
Hansmann (Hansmann M et al., 1978)	1978	EFW = – 0.001665958 ATD3 + 0.4133629 ATD2 – 0.5580294 ATD – 0.01231535 BPD3 + 3.702 BPD2 – 330.1811 BPD – 0.4937199 GA3 + 55.958061 GA2 – 2034.3901 GA + 32 768.19
Merz (Merz E. et al., 1988)	1988	EFW = – 3200.40479 + 157.07186 AC + 15.90391 BPD2
Warsof (Warsof SL et al., 1977)	1977	Log10 EFW = – 1.599 + 0.144 BPD + 0.032 AC – 0.111 (BPD2 × AC)/1 000
Campbell, Wilkin (Campbell S and Wilkin D, 1975)	1975	Loge EFW = – 4.564 + 0.282 AC – 0.00331 AC2
Shepard (Shepard MJ et al., 1982)	1982	Log10 EFW = – 1.7492 + 0.166 BPD + 0.046 AC – 2.646 (AC × BPD)/1 000
Schild (female) (Schild RL et al., 2004)	2004	EFW = – 4 035.275 + 1.143 BPD3 + 1 159.878 AC1/2 + 10.079 FL3 – 81.277 × FL2
Schild (male) (Schild RL et al., 2004)	2004	EFW = 43576.579 + 1913.853 × log10 BPD + 0.01323 HC3 + 55.532 AC2 – 13 602.664 AC1/2 – 0.721 AC3 + 2.31 FL3

(AC, abdominal circumference; ATD, abdominal transverse diameter; BPD, biparietal diameter; EFW, estimated fetal weight; FL, femur length; GA, gestational age; HC, head circumference)

Notably, Hansmann et al. also included gestational age, and the formula presented by Schild et al. included fetal gender. Most of these methods have insignificant systemic errors, but random errors of less than approximately 7 % are rarely reported indicating a general lack of accuracy ***(Siemer et al., 2009).***

It could be concluded that while all formulae have adequate accuracy for estimating fetal weight, Hadlock IV has the best accuracy ***(Kumaral and Hemantha, 2009).***

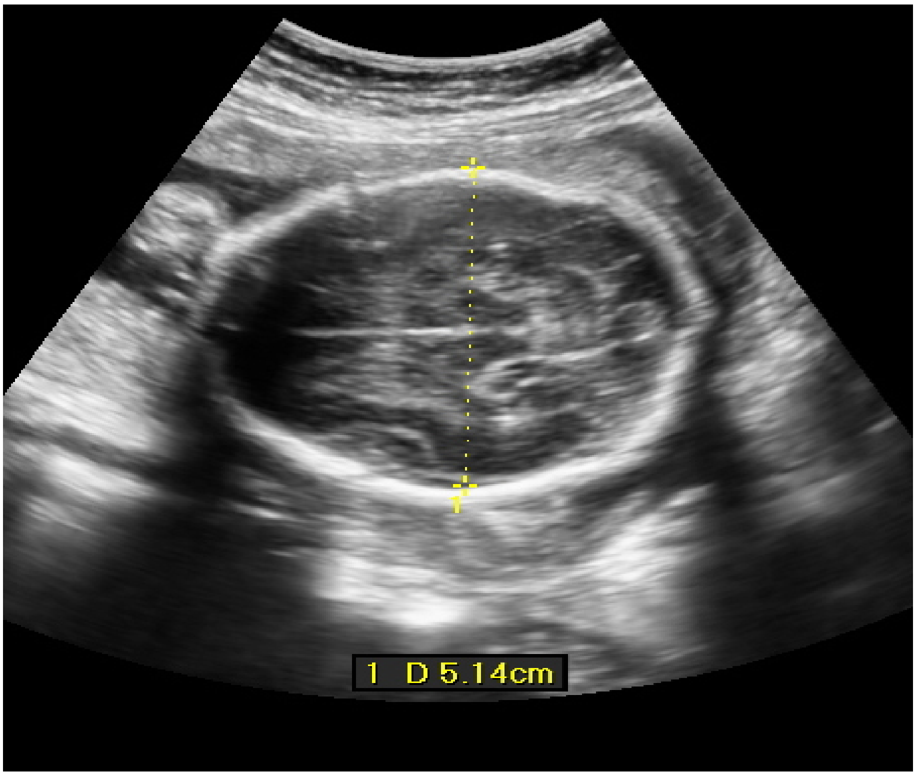

Figure (2): Transverse axial sonogram of the fetal head: measurement of biparietal diameter ***(http://www.samsungmedison.com/ultrasound)***