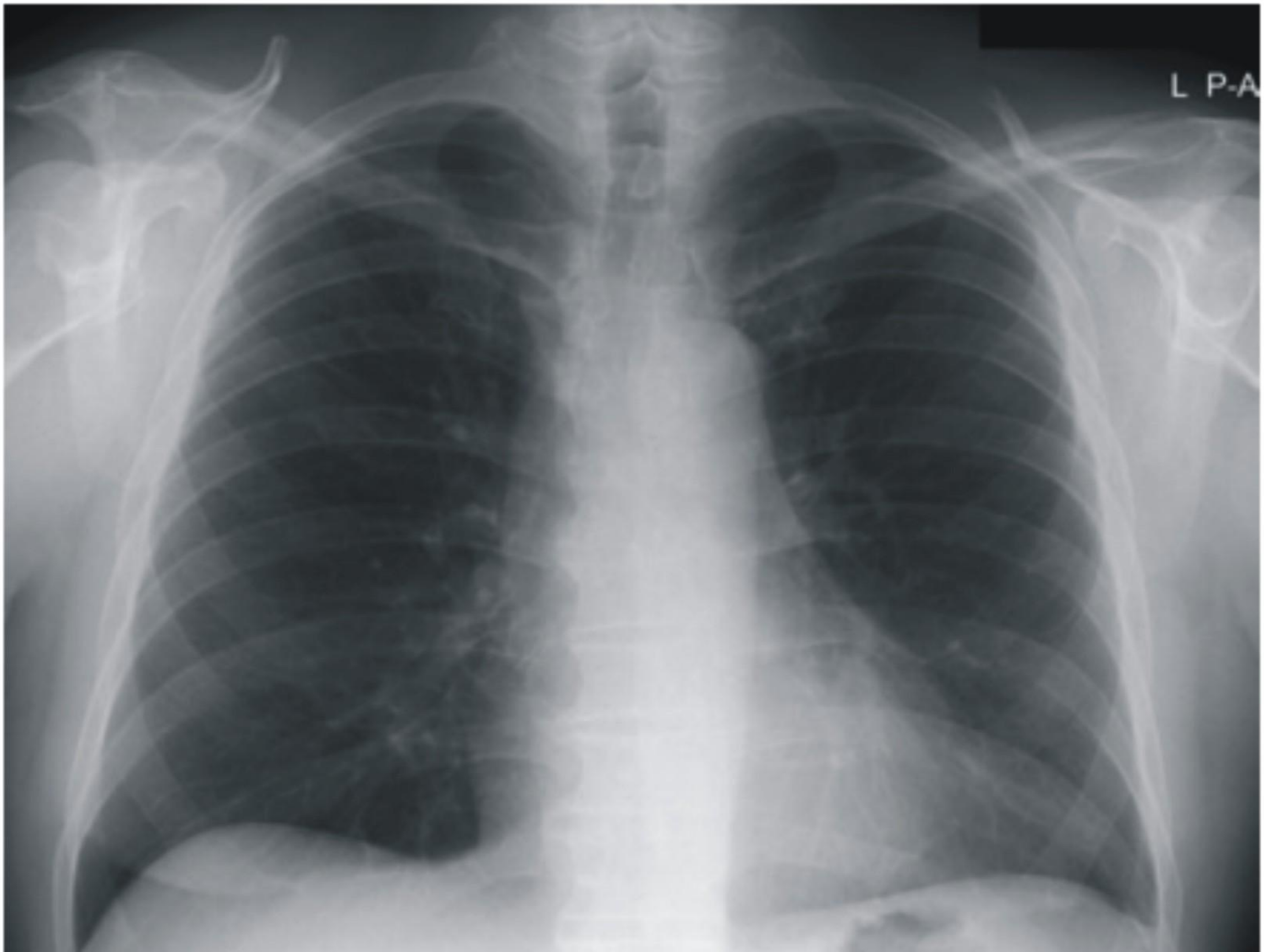
The Association Of Radiographers Of Nigeria
EYE OF MEDICINE

JOURNAL OF THE ASSOCIATION OF RADIOGRAPHERS OF NIGERIA

ISSN: 1115- 7976 Vol 30, Issue 1, December, 2016

The Official Journal of The Association of Radiographers of Nigeria

J A R N



Journal homepage: www.jarnxray.org

Validation Study of Hadlock3 Model of Foetal Weight Estimation

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Received: 6 December, 2015. Received in revised form: 5April, 2016. Accepted: 30 April, 2016

ABSTRACT

Aim: The aim of this study was to evaluate the validity of Hadlock 3 model of foetal weight estimation among fetuses in a Nigerian population.

Methods: 2008 mothers with singleton term pregnancy admitted in the labour ward of Ebonyi State University Teaching Hospital for planned delivery were recruited for the study. Subjects who met the inclusion criteria were scanned within 24 hours prior to delivery. A greyscale high resolution ultrasound machine, Sonoace 5500, manufactured by Medicol in Korea, with a 3.5 MHz transducer was used to obtain the sonographic measurements. The birth weights of the fetuses were estimated using Hadlock3 model for foetal weight estimation. The actual weights of the neonates were measured immediately after birth by an experienced midwife. Intra-class correlation coefficient was used to compare the ultrasound estimated fetal weight with the actual fetal birth weight.

Results: The mean actual birth weight of the neonates was 3.42 ± 0.36 kg while the mean estimate obtained from Hadlock3 model was 3.44 ± 0.45kg. There was no statistically significant difference between the estimated mean weight and the actual weight of the neonates at the reference birth weight ($P < 0.05$). The accuracy of this model was highest at the weight range of 3.00 to 3.99 kg, with inter-class co-efficient of 0.88 and accuracy of 86 % within ± 10 % of actual birth weight.

Conclusion: Hadlock3 model has a high intra-class correlation coefficient of 0.88 at birth weight of 3.00 to 3.49 kg and predicts the birth weight in 86% of cases within ± 10% of actual birth weight.
Keywords: Inter-class, Sonography, Evaluation, Pregnancy, intra-partum.

Introduction

In 1985, Hardlock and co-workers published a model for foetal weight estimation popularly known as Hardlock3 model of foetal weight estimation. The method makes use of the sonographically measured foetal abdominal circumference (AC),the biparietal diameter (BPD), and femur length (FL) to estimate foetal weight [1]. Many researchers have used different methods to propose an estimate of foetal birth weight with the most commonly used method as ultrasonographic and clinical approaches [2].

Ultrasonographic estimation of foetal birth weight has been assessed in different ethnic groups [1,3-5], and has been found to be a very useful tool in the management of term pregnancy [6]. Different models of ultrasonographic foetal weight estimation have been proposed. Most of these model have been derived using data from western population [1, 4, 7-10], which might differ from those in other parts of the world. Secular changes and ethnicity have been shown to affect birth weight [10-14].

It has also been demonstrated that birth weight standards change over time [13, 14]. For instance, studies have shown that fetuses delivered at winter had different birth weight pattern/standard from those delivered at summer [13,14].

The Hardlock3 model was derived using data from western population [1], and from our working experience and local findings, it appears to be the most popularly used model of foetal weight estimation in the southern part of Nigeria. However, the accuracy of this model among the Southeast populations of Nigeria has not been evaluated.

Knowledge of foetal weight is important in the management of labour and delivery. Management of diabetic pregnancy, vaginal birth after a previous caesarean section and intra-partum management of fetuses presenting breech will be, to a large extent, dependent on the estimated foetal weight [6, 15, 16].

Perinatal morbidity and mortality is still a major problem in the developing countries such as Nigeria [17], and foetal birth weight remains one of the most important parameters that determine neonatal survival [18-21], and adverse developmental outcome [22,23]. Again, knowledge of the weight of the foetus in utero could provide the clinician with necessary information that helps him decide the time of delivery, the mode of delivery and if there would be need for specific obstetric intervention. It could also help the clinician decide the place or center of such delivery, bearing in mind the possible need for some specific neonatal care equipment.

Presently, all available methods and techniques for estimating foetal weight have some degree of inaccuracy [2], and several studies have been done to compare the accuracy of some of these methods. Knowing the complications and dangers associated with fetuses at extremes (too low or too high) of birth weight requires that accurate estimation of the foetal weight be made in advance of delivery [15, 24, 26]. The aim of this study was to evaluate the validity of Hadlock3 model of foetal weight estimation among a Nigerian population.

Material and Methods

Subjects included in this study were women with singleton term pregnancy (37 to 42 weeks) admitted in the labour ward of Ebonyi State University Teaching Hospital, Abakaliki, Nigeria, from January to December, 2010, for planned delivery. The Human Right and Ethics Committee of the hospital approved the study. There were 2008 subjects aged 20-41 years, (mean age = 29 years) that met the inclusion criteria. These include: the couple must be both ethnic Southeast Nigerians, the pregnancy must be singleton and at term, the gestational age must have been confirmed with last menstrual period (LMP) and ultrasound scan performed prior to 20 weeks of gestation. Subjects with multiple pregnancy, eclampsia polyhydramnious, oligohydramnious pre-mature rupture of membrane, pre-term labour, and previous congenital anomalies were excluded from the study. Data from women delivered within 24 hours after the ultrasound examination were the ones used for the study. The rest were discarded. The aim and the procedures of the study were explained to the subjects and they all gave informed consent.

The subjects were positioned supine on the examination couch and made comfortable with pillows. Clothing were adjusted to reveal the bare skin of the abdomen. Ultrasound transmission gel was then applied on the abdomen. Siemen SL2 ultrasound machine (Siemen Medicals, Germany), with a 3.5 MHz linear transducer was used for the measured parameters.

The measured parameters were abdominal circumference (AC), biparietal diameter (BPD), head circumference (HC) and femur length (FL). The abdominal circumference was measured on a transverse section through the foetal abdomen when an ovoid shape of the abdomen was obtained as described by previous studies [5, 12]. The biparietal diameter was taken at a level that shows the thalami, the cavum septi pellucidum, the intra-hemispheric fissure, and the third ventricle [26], and at a point where the continuous midline echo is broken by the septum pellucidum cavum [2]. The femur length was measured when the full length of the femur was identified and measurement was taken along an axis that shows both the round echopenic cartilaginous femoral head and the femoral condyles [26,28]. All measurements were taken by a single well experienced sonographer. The neonates were weighed immediately after birth by experienced midwives who had no knowledge of the sonographic values and the study. Weighing was done using a standard analogue waymaster (England) scale with the pointer at zero. The sonographic estimated weight and the actual birth weight of the neonates were recorded for comparison.

Data Analysis

The participating subjects were grouped according to their gestational age (from 37 to 42 weeks). The actual birth weights of the neonates were grouped into 4 (from 2.00 to 4.49kg). Grouping enabled statistical comparison of the intra-class correlation coefficient of each group. This gave an index of the reliability of the tested model in each weight group. The statistical package for social science version 14.0 was used to analyze the data. Statistical level of significance was taken at $p < 0.05$. Assessment of the validity of the tested model was determined by the intra-class correlation coefficient and the mean difference between the estimated weight and the actual birth weight [29]. The inter-class correlation coefficient is a means of quantitatively assessing the concordance and variation between the estimated weights and the actual birth weight. T-test was used to assess the mean difference between foetal weight obtained using Hadlock3 model, and the actual birth weight. The data analyzed had a normal distribution.

Results

The mean gestational age was 39 ± 1.3 weeks. The actual weight distribution in the various gestational ages is shown in Table 3. The estimates of Hadlock3 model compared with actual birth weight in the various age groups is shown in Table 2. The mean actual birth weight of the neonates was 3.42 ± 0.36 kg while the mean estimate obtained from Hadlock3 model was 3.44 ± 0.45kg. There was no statistically significant difference between the estimated mean weight and the actual weight of the neonates at the reference birth weight ($p < 0.05$). The accuracy of this model was highest at the weight range of 3. 00 to 3.99kg (Table 3) with inter-class co-efficient of 0.88 and accuracy of 86 % within ±10 % of actual birth weight (Table 4). The accuracy of Hadlock3 model was lowest at birth group of 4.00 to 4.49kg where the model underestimated the birth weight (Table 2).

Discussion

Accurate prediction of foetal weight is of great value in obstetrics and since foetal weight cannot be measured directly, it is usually estimated from maternal anatomical characteristics or foetal parameters [2]. Different foetal parameters are used by different authors in derivations of equations for estimating fetal birth weight (Table 1). The degree of accuracy of these models differ in different ethnic groups [1].The accuracy of Hadlock3 model in this study was highest at the weight range of 3.00 to 3.99kg (Table 3) with inter-class correlation co-efficient of 0.88 and accuracy of 86% within ± 10 % of actual birth weight (Table 4). Intra-class correlation coefficient of 0.88 obtained in our study is higher than 0.86 obtained by Pang and co-worker [3] when Hadlock3 model was evaluated among the ethnic Chinese.

Different results obtained by different researchers agree with the findings of earlier study[3,13] that ethnicity potentially, played an important role in the foetal body weight estimation. This is thought to be due to differences in genetic and hormonal compositions of the different groups studied. Again, studies have shown that foetuses delivered at winter had different birth weight pattern/standard from those delivered at summer [13,14]. This gives an impression of possible influence of weather on foetal birth weight pattern.

Previous studies have equally shown that models that include head HC among other parameters, FL,BPD,AC of the foetus in the derivation of the formulae, tend to give a closer estimate of the true birth weight than those that rely on BPD alone as a predictor of head shape [9,30,31]. This could be because HC gives a better description of head shape than BPD. Variation in shape of foetal head could affect the precision of the estimates [30].

The accuracy of different foetal weight estimation models has been questioned [32], and has been shown to vary with different birth weight groups [33]. This phenomenon is observed in this study in that the accuracy of Hadlock3 model dropped significantly at birth weight greater than 4.00kg. This could be due to the difficulties experienced in obtaining valid measurements of the head when it is deeply engaged in the pelvic which is usually seen in big foetuses. The accuracy of Hadlock model of foetal weight estimation had in recent studies been shown to be quite accurate among the Bangladeshi [32]. The present study also confirms its accuracy among Southern Nigerians.

In conclusion, Hadlock3 model has a good (86%) and acceptable degrees of accuracy in foetal weight estimation at the weight range of 3.00 to 4.00 kg among the ethnic South East Nigerians. Further studies are therefore, necessary to establish valid birth weight estimation models for foetuses with extremes of birth weight.

Table 1: Published models for ultrasonic foetal weight estimation

Source	Year	Equation
Shepard	1983	$Log_{10}BW=1.7492+0.0166(BPD)+0.0046(AC)-0.00002646(AC_{X}BPD)$
CAMPBELL	1975	$L_{n}BW=4.564+0.0282(AC)-0.00000331(AC)^{2}$
HADLOCK 1	1985	$Log_{10}BW=1.326-0.0000326(AC_{X}FL)_{X}0.00107(HC)+0.00438(AC)+0.0158 (FL)$
HADLOCK 2	1985	$Log10BW =1.304+0.005251(AC)+0.01938(FL)0.00004(AC_{X}FL)$
HADLOCK 3	1985	$Log_{10}BW=1.335-0.000034(ACxFL)+0.00316x(BPD)+0.0045(AC)+0.01623(FL)$
WARSOF 1	1986	$LnBW=4694+0.00151(FL)^{2}-0.0000119(FL)^{3}$
WARSOF 2	1986	$LnBW=2792+0.108(FL)+0.000036(AC)^{2}-0.00027(FLXAC)$
COMBS	1993	$BW=(0.00023718_{X}(AC)^{2}{}_{X}(FL)^{2})+0.00003312(HC)^{3}$
OTT	1986	$Log_{10}BW=0.004355(HC)+0.005394(AC)-0.00008582(HCXAC)+1.2594(FL/AC)-2.0661$
NZEH et al. (FORMULA 1)	1992	$Log_{10}BW=0.470+0.488Log_{10}BPD+0.554Log^{10}fl+1.377Log_{10}AC$
NZEH et al(FORMULA 2)	1992	$Loh10BW=0.326+0.00451(SDI)=0.383$ $Log_{10}BPD+0.614Log_{10}FL+1.485Log_{10}AC$
DETTER	1985	$EFW=10^{1.335-0.0034ACXFL+0.0316BPD+0.0457AC+0.1623FL}$

Ref [2]

Table 2: Hadlock3 estimates of fetal weight vs. actual birth weight

Weight group (weeks)	USEW(kg)	ABW (kg	P
2.00 - 2.49	2.35 ± 1.33	2.31 ± 0.23	0.07 (NS)
2.50 - 3.49	2.72 ± 2.10	2.78 ± 0.35	0.09 (NS)
3.00 - 3.49	3.33 ± 1.74	3.31 ± 0.21	1.32 (NS)
3.50 - 3.99	3.64 ± 1.72	3.65 ± 0.20	1.31 (NS)
4.00 - 4.49	4.32 ± 1.09	4.05 ± 0.51	0.03 (S)

Table 3: Inter-class correlation-coefficients and 95% confidence interval of estimated foetal weight and actual birth weight (ABW)

Foetal	Coefficient	Coefficient Interval
2.00 - 2.49	0.85	0.78 – 0.90
2.50 - 2.99	0.86	0.8 – 0.91
3.00 – 3.49	0.88	0.80 - 0.93
3.50 - 3.99	0.88	0.82 - 0.94
4.00 - 4.49	0.55	0.45 - 0.61

Table 4: Accuracy of the estimation within ± 10% of actual birth weight in the various weight groups

Weight group	±10% accuracy
2.00 - 2.49	70
2.50 - 2.99	75
3.00 - 3.49	86
3.50 - 3.99	86
4.00 - 4.49	45

Conflict of interest: None declared

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How to cite: Udoh B E, Eduwem UD, Ulu O U. Validation Study of Hadlock3 Model of Foetal Weight Estimation. J Assoc Rad Niger, 2016; 30 (1): 1 – 7.