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July 2010

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Abstract

Objective: To develop a sonographic birth weight estimation model for Pakistani population and to validate the published models in the same population.

Methods: Data was collected for pregnant women who presented to Radiology Department of Aga Khan University Hospital Karachi from January 2007 to July 2008 and had undergone ultrasound estimation of foetal weight within 4 days prior to a term delivery (37-42 weeks gestation). The neonate's actual birth weight was used to validate the published foetal weight estimation models and modified sonographic birth weight estimation model was derived for our population by using linear regression.

Results: Modified sonographic birth weight estimation model for our population was derived by using foetal parameters. No significant difference (p-value >0.05) of actual and predicted birth weight derived from Our regression model, Campbell and Woo models was noted, however least difference (p = 0.7) was identified between our predicted model (Mean difference 14 ± 37.7g).

Conclusion: Our sonographic modified regression model of foetal weight estimation gave the least difference with actual neonatal birth weight and can be reliably used in our population. Hadlock1, Hadlock2 and Woo2 models are not appropriate in our setting or should be used carefully while predicting foetal weight in our population (JPMA 60:517; 2010).

Introduction

Birth weight is significantly associated with the child's mental and physical health.[1] Low birth weight (<2500 g) and extremely low birth weight (<1500 g) are strongly correlated with neonatal morbidity, mortality and abnormal developmental outcomes,[1,2] and needs urgent and effective obstetrical and neonatal management.[3] On the other hand macrosomic babies (>4000g) have a six fold increased probability of birth trauma and subsequent injury.[4,5] The antenatal birth weight estimation has tremendous value in obstetric and neonatal management in terms of appropriate time of delivery, specific obstetrical interventions, delivery under intensive neonatal care support. Accurate estimation of foetal weight is an important measurement for obstetricians towards labour management. It is

also helpful in parents counseling for future consequences related to their new born. Foetal weight is also an important part of antenatal care to assess foetal growth in the uterus for detecting intra uterine growth retardation.

Clinical approaches of foetal weight estimations by fundal height measurements and abdominal palpations are helpful but subjective and strongly influenced by maternal obesity, multiple gestations and operator experience.[6,7] In addition these approaches are non-technical and cannot be reliably used in early stages of pregnancy.

Use of ultrasonography for foetal weight estimation was first reported by Campbell and Wilkin[8] and Higginbottom et al.[9] This method has been in clinical use for more than three decades and at present Sonography is the most widely and accepted method for foetal weight estimation and many studies have emphasized the usefulness of this measurement in monitoring normal foetal growth and in detecting intrauterine growth retardation, macrosomia and isoimmunization.[10-14] Several models for sonographic foetal weight estimations have been generated by various investigators using different combination of foetal biometric measurements.[8,9,15-20] No consensus has been drafted so far to which model gives a better validity for predicting foetal weight in obstetric sonographic practice. The use of particular model is mainly based on preference of the individual obstetrician or radiologist.

Almost all sonographic foetal weight estimation models have been derived from data of western populations[8,9,16-18] and only Woo et al[19] used Chinese data for foetal weight estimation model within Hong Kong. In published resources it has not been identified if any sonographic birth weight estimation model is established for Pakistani population as well as for other South East Asian region.

Population differences, ethnicity and secular changes are known to affect birth weight.[11,21-22] Anthropological variation of the selected population may change the equation form of published sonographic foetal weight estimation models derived from western population data. Birth weight estimation models derived from other ethnic population applied in our locality might result in systemic erroneous estimations. Therefore the primary objective of this study was to develop the sonographic birth weight estimation model for Pakistani population and secondary objective was to validate the published models for the same population.

Subjects and Methods

Data was collected in the Radiology Department of Aga Khan University Hospital Karachi from January 2007 to July 2008. All pregnant women with singleton pregnancy, Pakistani ethnicity and confirmed gestational age, who were referred to Radiology Department from the period of July 2006-August 2007 for ultrasound examination within four

days of delivery, were included in this study. Exclusion criteria were the presence of any foetal congenital abnormalities on ultrasound, and patient's having underlying chronic diseases or non-availability of follow-up and birth weight.

To detect a difference of 0.2 between the null hypothesis correlation of 0.5 and the alternative hypothesis correlation of 0.75 using two sided hypothesis test with significance level of 0.05 and power of 80%, a sample of at least 46 were required to fulfill the objectives of study. All ultrasounds were performed by more than one qualified radiologists to measure biparietal diameter (BPD), femur length (FL) and abdominal circumference (AC) measurements of foetus in standardized way by using electronic caliper installed in U/S machine. The BPD was estimated from the outer to inner edge of skull at the level of the cavum septum pellucidum.[23] Femur length was measured according to the method of O'Brien et al[24] while foetal abdominal area and AC was measured at the level of the umbilical vein[8] by tracing the outline of the trunk on the screen of the ultrasound machine. The outline is circular or elliptical and includes the foetal spine, umbilical vein, and stomach. Three measurements were made for each variable, and all the measurements were in centimeters. All measurements were done by using a real-time ultrasound scanner (Aloka SSD-650, Tokyo, Japan) using a 3.5-MHz curvilinear probe.

The newborn birth weights (in grams) were measured independently of the ultrasonic in uterus weight estimation immediately after birth by using digital baby scale. Pre defined Performa was used for data collection, data was entered and analyzed in SPSS 16.0.

The continuous and ordinal variables were summarized first with descriptive statistics to check the central tendency and normality. The relationship between sonographic foetal biometric measurements (BPD, FL, and AC) and actual birth weight was evaluated by stepwise linear regression analysis. Further analysis was done with the objective of developing the best-fitted birth weight predicting model with one or more sonographic foetal measurements combination. In model -1 (Waseem 1) foetal abdominal circumference was taken for birth weight prediction. Model-2 (Waseem 2) comprises of foetal abdominal circumference and biparietal diameter for birth weight prediction. In model-3 (Waseem 3) foetal abdominal circumference and femur length was taken as predictor of birth weight. Model-4 (Waseem 4) comprises of all foetal parameters including abdominal circumference, biparietal diameter and femur length for birth weight estimation. All of the models developed in this study (Waseem1-4) and those developed from Campbell and Wilkin (8), Woo et al (19) and Hadlock et al (16) were evaluated as birth weight predictors in our population. The main difference amongst all developed sonographic birth weight estimation models (Waseem 1-4) is use of different foetal parameters and

their combination for birth weight prediction. P-value less than 0.05 was considered significant.

Results

A total of 1200 pregnancies with radiological record were identified. Out of these only 66 patients were fulfilling the inclusion criteria and were analyzed. There were 33 vaginal deliveries and 33 elective caesarian sections. Birth weights ranged from 1700 to 4100 grams (mean 2765.66 ± 601.47). The birth weights were normally distributed (p-value 0.817). By applying linear regression four birth weights predicted models were developed in this study (Waseem1-4). In model-1 log of birth weight is predicted to increase 0.136 when AC goes up by one centimeter, decreased by 0.002 when AC square goes up one centimeter and is predicted to be 0.708 when AC is zero. In model-2 log of birth weight is predicted to increase 0.099 when AC goes up by one centimeter, decreased by 0.001 when AC square goes up one centimeter, increased by 0.056 when BPD goes up one centimeter and is predicted to be 0.949 when both AC and BPD are zero. For model-3 log of birth weight is predicted to increase 0.204 when Ac goes up by one centimeter and increase 0.935 when FL goes up by one centimeter and decreased by 0.027 when multiplicative term of AC and FL goes up one centimeter square and is predicted to

be -0.949 when both AC and FL are zero. In model-4 log, birth weight is predicted to increase by 0.147 when Ac goes up by one centimeter and increase by 0.088 when BPD goes up one centimeter and increase by 0.652 when FL goes up one centimeter and decrease by 0.020 when multiplicative term of AC and FL goes up one centimeter square and is predicted to be -2.213 when both AC, BPD and FL are zero.

The significant regression models (p-value <0.05) developed in this study are summarized in Table-1. The mean along with standard deviation of predicted birth weight by using models developed in this study, different published models (8, 16, 19-21) and foetal biometric measurement are described in Table-2. No significant difference was identified between predicted and actual birth weight by using one of the models of this study which comprises of foetal BPD, FL and AC (waseem4). The mean differences in birth weight were also insignificant by applying Campbell and Woo 1 model but both models underestimate foetal weights (-73g and -149g respectively). Least mean difference (only 15g) was noted by using predicted model developed in this study (waseem4). The results of this study suggest, that anthropological differences in our foetuses may change the equations of sonographic birth weight estimation model developed from other population;

Table-1: Comparison of Foetal Weight Estimates Using Optimal Regression Models derived from study (Waseem[1-4]). (n=60).

Fetal Parameters	Regression Equation	R^2 (%)
AC[1]	Log_{10} BW= 0.708+ 0.136 (AC) -0.002 (AC^2)	76.5
AC, BPD[2]	Log_{10} BW= 0.949+0.099 (AC) -0.001 (AC^2)+ 0.056 (BPD)	79.6
AC, FL[3]	Log_{10} BW= -3.548+ 0.204 (AC) + 0.935 (FL) -0.027 (ACXFL)	66.0
AC, BPD, FL[4]	Log_{10} BW= -2.213+ .147 (AC)+.088 (BPD)+ .652 (FL) -0.020 (ACXFL)	75.9

Table-2: Ultrasonic foetal biometry, estimated birth weight, and actual birth weight of the study population.

Parameter	Mean	SD
*Biparietal diameter (BPD)	8.9	0.5
*Abdominal Circumference (AC)	32	5.1
*Femur Length (FL)	6.9	0.4
+Actual Birth Weight	2766	601

+Estimated Foetal Weight

	Mean	SD	Mean difference	!P-value
Waseem[1]	986	123	1779.23	<0.001
Waseem[2]	3935	1014	-1169.75	<0.001
Waseem[3]	2875	479	-109.76	0.03
Waseem[4]	2751	519	14.34	0.70
Campbell	2839	446	-73.45	0.09
Wool[1]	2915	934	-149.99	0.15
Wool[2]	3546	1261	-781.09	<0.001
loghadlock[1]	2775	566	2762.23	<0.001
loghadlock[2]	1626	477	1139.55	<0.001

therefore selection of appropriate or validated sonographic model is warranted in our population.

Discussion

The results of this study clearly demonstrate that anthropological variations within population may change the predicted equation for sonographic foetal weight estimation and validation or judicious selection of appropriate prediction model should be made for precision. The results are consistent with published literature.[8,11,16,19-21] Sonographic birth weight estimation model other than our population developed by Campbell[8] and Woo[19] gave closest birth weights. Previous studies have shown that prediction models developed with use of all foetal parameters including FL, BPD and AC are more accurate for foetal weight estimation.[15-16,19] This finding is consistent with our results as one of the model developed in this study having all foetal parameters gave minimal difference between predicted and actual birth weight. Campbell and Higginbottom et al[8,9] have shown that AC is a good indicator of foetal weight but this is not consistent with our findings. This could be due to normal small babies having low birth weight as compared to babies born in the developed world. Addition of femur length (FL) in regression equations improved birth weight estimation in our study this could be based on the fact of linear relationship of FL with crown-heel length.

Addition of head circumference and foetal sex[25] in regression model could produce better estimation of birth weight but these two predictors were not assessed in this study. Foetal and maternal conditions are known to effect birth weight but all foetuses included in the analysis of this study were normal and mothers had no known comorbids. Multiple ethnicities are known within our population and these were not addressed in this study. Neonatal birth weight in this study ranges from 1700-4100 grams; foetuses having weight outside these limits require another study for foetal weight estimation. Secular changes are known to effect birth weight therefore sonographic birth weight estimation model derived from our population in this study requires re-validation after certain time period.

Conclusion

Ultrasound is a good, reliable and safe modality for prediction of foetal weight, however selection of appropriate estimation model in the context of local population is important. Prediction sonographic model developed for the Pakistani population in this study can be used for sonographic foetal weight estimation, however all users should analyze these measurements in their local context as subtle differences in imaging and measurement technique may change the predicted equation.

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