Fetal Weight Estimation: Importance, Challenges and Emerging Trends

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Abstract

Accurate fetal weight estimation is important in preventing and managing fetal and maternal complications. Many fetal weight formulae have been derived, but none seems to be accurate enough to be applied globally for all ranges of fetal weight. Major factors causing errors in fetal weight estimation include inappropriately derived equations not considering ethnic differences among populations, fetal gender difference and different ranges of fetal weight. Use of fetal thigh volume and arm volume for fetal weight estimation by 3D ultrasound may increase the precision of fetal weight formulae. However, the superiority of 3D ultrasound in fetal weight estimation over 2D ultrasound is debatable as greater expertise is required, time consumed is more and there is no substantial increase in accuracy. It is suggested that fetal gender specific, fetal weight range specific and community based formula should be derived and used for better accuracy. Further studies are recommended. Articles published between October 1993 to October 2015 were selected from PubMed and Google Scholar, for this review article.

Keywords: Fetal weight estimation, sonography, femur, biparietal diameter, gender.

Fetal weight and its importance

Fetal weight estimation is an integral part of obstetrical examination and management planning. It is important to calculate fetal weight with precision as both increased and decreased fetal weight can result in complications during labor and puerperium¹⁻³. Complications like preterm delivery⁴⁻⁶ or intrauterine growth restriction (IUGR) are known to be associated with low fetal weight⁷⁻⁸. Fetal bone injuries, shoulder dystocia and brachial plexus injuries are reported with large fetal weight⁹⁻¹⁰. Similarly, maternal complications like pelvic floor and birth ca-

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Annals Abbasi Shaheed Hospital & Karachi Medical & Dental College
and some are based on three or more parameters like Aoki’s formula and Hadlock’s formula. Which formula is better than the other has been scrutinized by many researchers reporting conflicting results\textsuperscript{15}. Some studies suggest that increasing the number of parameters can improve the accuracy of the formula while few suggest that it does not make any substantial difference on the accuracy of the equation\textsuperscript{16}. Formulae including abdominal parameters like abdominal circumference are reported to have better accuracy in measuring fetal weight. It may be because, as reported by researchers, they indirectly incorporate fetal liver growth and hepatic glycogen stores reflecting fetal nutritional status. Liver being the largest organ of abdomen greatly influences both fetal abdominal parameters and fetal weight\textsuperscript{17}.

Among these formulae, Hadlock, Campbell, Shepard and Aoki fetal weight formulae are widely used and tested by researchers\textsuperscript{18}. Royal College of Obstetrics and Gynaecology reported Shepard and Aoki formulae to have better accuracy in predicting fetal weight within the normal range of fetal weight but their use outside the normal range is suggested to be inappropriate\textsuperscript{19}. Better accuracy obtained from Aoki’s formula might be due to use of three fetal parameters that are biparietal diameter, fetal abdominal area and femur length. However, same level of accuracy is reported with Shepard formula which uses only two fetal parameters which are biparietal diameter and abdominal circumference\textsuperscript{20}. Campbell formula is easier to use as it requires only one fetal parameter to be measured which is abdominal circumference, is reported to be as good as any other formula for average weighed infants\textsuperscript{21}. It is also reported to be a better formulae in cases of fetal macrosomia\textsuperscript{14}. Hadlocks formulae which uses four fetal parameters including head circumference, biparietal diameter, femur length and abdominal circumference is reported by researchers to be as accurate as other fetal weight formulae\textsuperscript{22}. Better performance of Hadlock formulae is also reported for all weight ranges\textsuperscript{23}. However, Royal College of Obstetrics and Gynecology guideline 2013 recommend Hadlocks formula for low weight fetuses\textsuperscript{19}

In Pakistan, the choice of using a particular fetal weight formulae depends on the individual obstetrician or radiologist. Although Hadlocks formulae is widely used in the country but Hadlock\textsuperscript{1} and Hadlock\textsuperscript{2} formulae were reported to be inappropriate for Pakistani population\textsuperscript{24}. For Pakistani population, a new fetal weight estimation formulae was suggested which was claimed to have more accuracy and reliability by the authors\textsuperscript{25}. Further studies are needed to evaluate it.

Majority of traditionally used formulae are neither population specific nor gender specific, and are used for all ranges of fetal weight\textsuperscript{26}. No single formula is accepted as a standard formula which could be applied globally with accuracy\textsuperscript{27,28}. The inaccuracies among these formulae vary greatly\textsuperscript{29}. Within the normal range of fetal weight the mean error is reported between 7 to 10%\textsuperscript{30}, but the error increases as fetal weight either increases or decreases beyond the normal fetal weight range\textsuperscript{31,32}. Most researchers suggest that fetal weight is under reported in cases of low birth weight and over reported in cases of high birth weight\textsuperscript{33}.

**Factors causing errors in fetal weight estimation**

Few reasons are suggested by different studies as the cause of inaccuracies in fetal weight estimation. Foremost among them is the use of inappropriate equations\textsuperscript{34} because different equations were derived using different set of population giving best result only for that population\textsuperscript{35}. Race and ethnicity are reported to affect the accuracy of fetal weight formulae considerably. Population specific equations are recommended for better accuracy\textsuperscript{36,37}.

Fetal gender is the other factor which affects the accuracy of fetal weight estimation. Most of the fetal weight formulae were derived not considering the effects of fetal gender on fetal weight\textsuperscript{26}. Researchers have reported that male and female fetuses show statistically significant differences in head circumference, biparietal diameter, abdominal circumference and femur length\textsuperscript{38}. Some researchers have also reported different growth patterns for
the two genders. Use of different formula coefficients for male and female fetuses are also recommended for better accuracy. Studies have also reported more inaccuracy in fetal weight estimation in female fetuses than in males suggesting the use of sex specific models for better accuracy of fetal weight estimation. In recent years, sex specific fetal weight estimation formulae have been reported to have better accuracy.

Breech presentation of the fetus has been reported to be a cause of inaccurate fetal weight estimation in different studies, but some researchers also claim that fetal weight estimation with breech presentation is as accurate as with vertex presentation. Twin pregnancy and inexperienced operator are other factors reported to decrease the accuracy of sonographic fetal weight estimation.

New approaches in 2D sonographic fetal weight estimation

In order to improve the accuracy of fetal weight estimation, recently new approaches and parameters have been suggested. Some researchers have recommended that fetal mid-thigh soft tissue thickness is a simple, easy and useful parameter for assessing fetal weight. It correlates well with estimated fetal weight and birth weight, and can be a valuable parameter for assessing fetal weight. Inclusion of fetal mid-thigh soft tissue thickness with routinely used parameters in fetal weight formulae can improve their accuracy. In 2D sonography, inclusion of soft tissue in fetal weight estimation can also be achieved by measuring fractional limb volume. Incorporating fractional limb volume in conventional fetal weight formulae have yielded better precision. A study conducted in Pakistan in 2008 reported that Isobe’s formula, which is based on femur length and cross sectional area of thigh, is more convenient and as accurate as other established fetal weight formulae.

Many researchers have shown that fetal weight formulae are not precise over the whole range of weight. Most fetal weight formulae perform better within a specific range of fetal weight. In order to improve the precision of fetal weight formulae, separate fetal weight formula were suggested for both low fetal weight as well as high fetal weight which are reported to have better accuracy.

Fetal weight estimation using fetal thigh volume, fetal arm volume by 3D ultrasound. A new approach

Recently 3D sonography has emerged as a new tool for estimating fetal weight. New fetal weight formulae are being developed and evaluated for accuracy. Parameters like fetal thigh volume, fetal arm volume and fetal liver volume are reported to have significant correlations with birth weight. Some studies suggest that incorporation of fetal thigh volume and fetal arm volume in fetal weight formulae may improve the accuracy of fetal weight estimation while same level of accuracy even after including fetal thigh volume and fetal arm volume in fetal weight formulae have also been reported in a few studies.

3D ultrasound versus 2D ultrasound for fetal weight estimation

Contradictions exist among studies in reporting the accuracy of fetal weight estimation by 3D ultrasound over 2D ultrasound. Some studies suggest 3D ultrasound to be better in estimating fetal weight while some suggest 2D ultrasound to be equally effective. However, extra time and expertise is required for estimating fetal weight with 3D ultrasound which could limit its use.

Standardized fetal growth parameters chart and fetal weight estimation

Large number of locally derived fetal growth charts and large variation in the reference points like 3rd percentile, 5th percentile or 10th percentile has made it difficult to establish whether the growth of the fetus is abnormal. A globally acceptable standardized fetal growth chart and fetal weight estimation is needed. To solve this problem University of Oxford, funded by Bill and Melinda Gates Foundation, started a multicenteric project named...
"Intergrowth - 21st Project" in 2009 with the aim to construct an internationally acceptable standard for fetal growth parameters and fetal weight estimation. From conception to infancy, anthropometric measures were developed. New internationally standardized fetal growth charts of parameters like biparietal diameter, head circumference, femur length, abdominal circumference were developed during this project which were published in 2014. In this project, from 14th week to 42nd week of gestation, sonographic evaluation was done after every 5th week. Abdominal circumference, occipitofrontal diameter, biparietal diameter, femur length and head circumference were measured. 3rd, 5th, 10th, 50th, 90th, 95th and 97th centile curves according to gestational age were developed which showed small differences between smoothed centiles and observed means. New sex-specific 3rd, 10th, 50th, 90th, and 97th centile curves for head circumference, weight and length of neonates according to gestational age at birth were developed. A new model for CRL measurement was developed for correct estimation of age of gestation. These international fetal growth standards are recommended for clinical application across populations. More results are awaited from this project.

Conclusion

Large number of fetal weight formulae applied in different parts of the world suggests that no standard and accurate fetal weight formula is available. Improvements can be made in the accuracy of fetal weight formula by considering the effect of gender and ethnicity while designing these formulae. Separate fetal weight formula for different fetal weight range could increase the accuracy of the formulae. Fetal weight estimation by 3D ultrasound using fetal thigh and arm volume has opened a new window of opportunity. Further research is needed to check if fetal weight estimation by 3D ultrasound is superior to 2D ultrasound. New international fetal growth standards are developed during "Intergrowth - 21st Project" which are recommended for clinical use across populations.

Conflict of interest

Authors have no conflict of interests and no grant/funding from any organization.

References


