Foetal weight estimation methods – Clinical, Sonographic and MRI imaging

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Abstract- Background: Knowledge of the weight of the foetus in utero is important for the obstetricians to decide the time and mode of delivery. It can be estimated clinically, biochemically or by radiological imaging .None of the diagnostic tools are direct .Interestingly clinically estimated foetal weight is being found more precise than radiological estimation

Aim:. This study was designed to find the error percentage in ultrasound and clinical methods. We also studied the research papers on the role of ultrasound and MRI in the diverse strata of birth weights.

Results: The average error in all the weight groups except in >3500 grams group was least with Dare's Formula, closely followed by Hadlock's Ultrasound Method. Average error in the >3500 grams group was least with Johnson's formula. For birth weight below 3500 grams clinical estimation by Dare's Formula gave the least average absolute error while in birth weights above 3500 grams clinical estimation by Johnson's Formula gave the least average absolute error. Dare's Formula had a tendency to underestimate the foetal weight and had least error in <3500 grams group. Johnson's and Ultrasound method overestimated the foetal weight. Ultrasound methods showed advantage in intrauterine growth restricted and macrosomic babies. MRI is important to detect central fat deposition in babies of diabetic and hypothyroid mothers.

Conclusion: The abdominal girth multiplication by symphysiofundal height can be a great concern in developing countries. It is easy and simple and can be used by even by midwives. Ultrasound may be reserved to detect abnormal blood flow in umbilical arteries in growth restricted babies and detecting central fat deposition in clinically macrosomic babies. This would ensure a better use of clinical and diagnostic modalities available to us

Index Terms- Abdominal girth, estimated foetal weight, MRI, Symphysio fundal height

I. Introduction

The Accurate estimation of foetal weight is important in modern obstetrics .During the past two decades estimated foetal weight is incorporated into the standard routine antepartum evaluation of high risk pregnancy. Management of diabetic pregnancy, vaginal birth after caesarean section and breech presentation is guided by the estimated foetal weight .(1,2).In preterm deliveries and intrauterine growth restriction, perinatal counselling on the likelihood of survival ,the intervention taken to postpone delivery ,optimal route of delivery or the level of hospital where delivery should occur is completely based on the estimated foetal weight (2,3,4,5).High rate of perinatal mortality (40 per 1000) is still a major concern in Tamil Nadu while compared to developed nations(3-4 /1000).A large proportion of this problem is related to birth weight which remains the single most important parameter that determines the neonatal survival(6,7,8,9).It is estimated that 16% of live born infants have low birth weight ,a condition associated with high perinatal mortality and morbidity. On the other hand foetal macrosomia is associated with maternal morbidity, shoulder dystocia, birth asphyxia and birth trauma (10).

Precise foetal weight estimation would help in successful management of labour and care of newborn. This will prepare us for any complications associated with low birth weight or macrosomia. Perinatal morbidity and mortality may decrease if timely intervention is undertaken (2, 3, 4, 11, 12).The available techniques can be broadly classified as

a) Clinical Methods: In clinical methods tactile assessment of foetal size, clinical risk factor estimation, Maternal self estimated foetal weight and Prediction equations of birth weight are included.
b) Imaging Methods: This includes ultrasonography and magnetic resonance imaging. Some investigators consider sonographic estimates to be superior to clinical estimates others confer similar level of accuracy. Several studies indicate that physician conducted physical examination of pregnant women and estimated foetal weight are superior to ultrasonic foetal measurement (3-7,12-46).Williams textbook concludes that estimation of foetal weight from ultrasonic measurements is not proven to be reliable(47).It even carries a risk of sonologically induced chromosomal anomalies.

II. Numerous RESEARCH Articles

Fetal weight estimation methods have been discussed by various authors.

Tactile assessment of foetal size

Dare et al used this technique by multiplying the abdominal girth (cm) with symphysiofundal height (cm) and calculated the estimated foetal weight in grams (21).However, this 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 (1, 26, 27, 29, 34).

Clinical risk Factor

This method involves quantitative assessment of clinical risk factors and has been shown to be valuable in predicting foetal weight. In case of foetal 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 foetal sex and white race should be added. In low estimated birth weight socioeconomic status, constitutionally small mother, poor maternal weight gain, foetal infections, congenital malformations, chromosomal abnormality, teratogenic exposure, maternal anaemia, Anti phospholipid Antibody syndrome and other medical disorders complicating pregnancy should be mentioned.

Maternal Self estimation

In literate society maternal self estimation of foetal birth weight in multiparous women show comparable accuracy to clinical palpation in some studies for predicting abnormally large foetus (24,29).

Birth weight Prediction equations

Various calculations and formulae based on measuring uterine fundal height above symphysis pubis have been developed. Ojwang et al used the product of symphysiofundal height and abdominal girth measurement at various levels in centimetres above symphysis pubis in obtaining a fairly acceptable predictive value but with considerable variation from the mean(20).Dare et al simplified and used the product of symphysiofundal height(Mc Donald's measurement) and abdominal girth at the level of umbilicus measured in centimetres and result expressed in grams to estimate foetal weight in uteru at term ,and the estimation correlated well with birth weight (21).
Johnson's formula for estimation of foetal weight in vertex presentation is as follows

Foetal weight (grams) = (Mc Donald's measurement of symphysiofundal 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.

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.

Obstetrical ultrasonography

Early expectations that this method might provide an objective standard for identifying foetus of abnormal size for gestation age was recently undermined by prospective studies that showed sonographic estimates of foetal weight to be no better than clinical palpation for predicting foetal weight (1, 26, 27, 29, 34).Susiki et al used ultrasound measurement of foetal heart volume to estimate foetal weight (44). Paulos et al used foetal volume by ultrasound (45). Sonographic predictions based on algorithms using various combinations of foetal parameters ,such as abdominal circumference (AC), Femur Length(FL), Biparietal Diameter (BPD),and Head Circumference (HC) both singly and in combination have been used (3,10,18,25,37-42).When other sonographic foetal measurements are used for estimating foetal weight e.g. humerous soft tissue thickness, ratio of subcutaneous tissue to, femur length, cheek to cheek distance, these nonstandard measurements do not help to predict birth weight except in special subgroups e.g. Diabetic mothers(32).Multiple sonographic foetal biometery also do not improve prediction(25,26). Foetal imaging is limited by maternal obesity, oligohydramnios and anterior placentation. Besides these formulas are obtained from populations which do not include pregnant women of all genetic background resulting in an inherent sampling error.

Magnetic Resonance Imaging

There is use of fast acquisition protocols, including echo planer MRI and T1 weighted and T2 weighted imaging for foetal volume calculation. The data so far does not suggest any better prediction (49, 50, 51, 52, 53, 54) than ultrasonography. For weight calculation, foetal volume is multiplied by foetal density although the exact value of latter is not known.In addition foetal density is a function of gestational age owing to changes in proportion of tissue represented by muscle, bone and fatty tissue. In majority of cases the authors selected a density value of 1.031g/ml (51, 52, 54, 55), but value of 1gm/ml (50) and 1.07 gm/ml (53) were also used .The great majority of measurements were calculated at term. As less adipose tissue is present at early gestational ages and growth restricted foetus, a different density value may be required for these estimations. Reported disadvantages of the method include higher cost and longer processing time (45 minutes).The vast number of articles published on the topic point that no currently available tool is precise. This study aims to determine the most accurate method of foetal weight estimation at term by comparing the various publications.

III. Discussion

Now it is the time to articulate the research work with ideas gathered in above steps by understanding the biophysics of fetal growth.

Biophysics of fetal growth

Human foetal growth is characterised by sequential patterns of tissue and organ growth, differentiation and maturation. This is determined, by maternal provision of substrate, placental transfer of these substrate and foetal growth potential governed by genomes. Foetal growth has been divided into three consecutive cell growth phases. The initial phase of hyperplasia occurs during the first sixteen weeks and is characterised by a rapid increase in cell number. The second phase which extends upto 32 weeks, includes both cellular hyperplasia and hypertrophy. After 32 weeks, foetal growth occurs via cellular hypertrophy and it is during this phase that most foetal fat and glycogen deposition take place (47).

The foetal growth is complex involving biophysical and biochemical dimensions. Although many factors have been implicated in the process of foetal growth, the precise cellular and molecular mechanism by which normal foetal growth occurs

is not well understood. The foetal growth rate is 5 gm/day at 15 weeks, 15-20 gms at 24 weeks and 30-35 gms at 34 weeks.

In early foetal life the major determinant of growth is foetal genome, but later in pregnancy environmental, nutritional and hormonal influences become increasingly important. There is a considerable evidence that insulin like growth factors and insulin (c –peptide) concentrations have a role in the regulation of foetal birth weight. Insulin like growth factors and insulin levels were measured throughout gestation in women without diabetes and it was found that levels correlated with birth weight. The insulin like growth factors , structurally proinsulin like peptide are produced by virtually by all foetal organs from early development and are potent stimulators of cell division and differentiation . Insulin like growth factor 1 and 2 and foetal insulin in umbilical circulation are all related to foetal growth and weight gain, but IGF-1 correlates best birth weight. Insulin is mainly related to foetal overgrowth (macrosomia) while IGF binding protein may be a growth inhibitor (47). Foetal fat deposition represents approximately 90% of calorie accretion at term. The quantity of foetal adipose tissue is the cause of incorrect estimation of weight by ultrasonography. Neonatal fat mass constitutes only 12-14 % of birth weight it explains 46% of its variance (22) .Foetal fat deposition in the extremities was found to be characterised by an exponential increase when plotted against gestational age (56). Since the discovery of the obesity gene and its protein product leptin, which is synthesised in adipose tissue there has been an interest in leptin levels in maternal and umbilical circulation. Foetal levels increase during the first two trimester and they correlate with birth weight.

Indirect Estimation

All currently available techniques have a significant degree of inaccuracy. The vast number of articles published on the topic point that no currently available tool is precise. A good estimate will help to screen high risk cases and timely perinatal management may reduce morbidity and mortality. Foetal weight is not directly proportional to foetal volume. Ultrasounds methods do not estimate foetal weight directly rather they do so indirectly by measuring the various segments of the body. Two dimensional ultrasonography is routinely used for the purpose, and the estimated foetal weight is calculated using appropriate tables or integrated computer programmes. The most frequently used parameters include the biparietal diameter, abdominal circumference and femur length. There is a cumulative error inherent in each of the foetal dimensions measured. Then, there is acoustic shadowing at extreme ends of diaphysis. A single formula is not capable of covering the entire range of foetal weight (22). Weight of smaller foetus tends to be overestimated while that of large foetus tends to be under estimated. The potential errors of measurement of each dimension add to the error when the values are put in a formula. So increasing the individual dimensions to be measured will only increase the error in the estimated foetal weight. Using three dimensional ultrasonography reproducible measurements of circumference and volume have become possible through simultaneous visualisation of three orthogonal foetal limb sections. This technique has the advantage of obtaining limb circumference measurements at the exact midpoints.

Advantage of MRI

Foetal volumetric measurements have also become a field of interest for magnetic resonance imaging. There is use of fast acquisition management protocols , including echoplaner MRI and T1 weighted and T2 weighted imaging for foetal volume calculation .Foetal volume can be calculated either using the Cavlieri principal or semi automatically with special software. None of the programmes available allow fully automatic volume assessment .For weight calculation; foetal volume is multiplied by foetal density although the exact value for the latter is not known. A recent concept is to MRI segment the foetal body into various compartments of different tissue consistency (56) .Volume of each segment can be multiplied with specific tissue density of each segment. The weights of each segment can be added to derive the total birth weight.

To Sum up

Clinical assessment of foetal weight is extensively used because it is both convenient and virtually costless. However, it is less accurate for an obese gravida and cases of polyhydraamnios. There is significant inter observer variation .But interestingly both nature (the inherent growth potential of the baby) and nurture (the nutritional status of the mother) are concurrently measured (47). The resultant estimates are closest to the actual birth weight as pointed out by several prospective studies. This study aims at resolving these controversies by determining the most accurate method of foetal weight estimation of the three available in our institute. We have made an attempt in standardising the methods of estimation and achieving the best estimated foetal weight.

Foetal macrosomia and intrauterine growth restriction has to be detected prenatally to reduce perinatal mortality and morbidity in term of long term neurological and developmental disorders (10). Intrauterine growth restriction after 37 weeks is an indication of immediate delivery. A diagnosis of macrosomia helps us to do a timely lower segment caesarean section and reduce the risk of macrosomia. The aim of our study was to reduce the perinatal morbidity by devising a protocol where we measure the biacromial diameter if the estimated foetal weight is two standard deviation above the mean. A Doppler study of umbilical artery should be added if estimated foetal weight is less than two standard deviation below the mean. This requires accurate assessment of foetal weight prenataly.

As foetal weight cannot be measured directly it has to be estimated from foetal and maternal anatomic and biochemical characteristics. Ultrasound only measures foetal characteristics. Interestingly, while intrauterine growth retarded babies have a compromised blood flow, macrosomic foetus do not have an increased uteroplacental blood flow. For, similar birth weight babies fat deposition is more in the foetus of diabetic mothers (47). The higher birth weight baby is an issue of abnormal content with preferential central fat deposition (56). Large foetus with truncal obesity should be differentiated from symmetrically large foetus. So an objective assessment of humeral soft tissue thickness and abdominal circumference should be measured and reported while estimating birth weight of higher orders (56). Clinical estimation is as accurate routine ultrasonographic estimation in average birth weight is emphasised by other authors as well (57).

All currently available techniques have a significant degree of inaccuracy. A vast number of articles published on the topic point that no currently available tool is precise.

IV. LEARNING POINTS

- Foetal growth is complex with biophysical and biochemical dimensions.
- Clinical estimates of birth weight are more precise than ultrasound estimations as they measure the growth potential of the foetus and nutritional status of mother collectively.
- Ultrasound formula measurements can be inaccurate as they are not representative of the genetic background and acoustic shadowing inhibits anatomical vision.
- Ultrasound Doppler can be used to measure umbilical artery vascular indices in cases of intrauterine growth restriction.
- 3-D ultrasound and MRI should be reserved for detecting central and peripheral fat deposition in macrosomic foetus.

V. COMPETING INTERESTS

We do not have any commercial association that might pose a conflict of interest in connection with the manuscript. We certify that neither this manuscript nor one with substantially similar content under our authorship has been published or is being considered for publication elsewhere.

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