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ORIGINAL ARTICLE

Longitudinal Study to Assess the Reliability and Predictive Validity of Ultrasound Measurements in Tracking Fetal Growth and Development Throughout Pregnancy

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ABSTRACT

The utilization of ultrasound in obstetrics is extremely common due to its accurate fetal imaging capabilities. By early identifying anomalies such intrauterine growth restrictions and macrosomia, ultrasonography scanning during pregnancy primarily aims to reduce the risk of obstetric problems. Fetal weight is currently estimated using morphometric formulas. They employ fundamental biometric variables. Hadlock's formula, which is used for estimation of fetal weight, has 20 percent error rate, though. Due to this particular cause, the researchers from all around world had already searching for the additional sonographic characteristics having a stronger predictive value that correlate with fetal weight. According to recent scientific studies, assessing fetal weight can benefit from using novel parameters of sonograph such measurements of the thickness of soft tissue. The fetus's body can be measured in a number of locations, including upper arm, the thigh, abdomen, and the subscapular region. Diverse measurements have varying degrees of connection with some other anthropometric & sonographic factors, including body mass & gestational age. Numerous research using novel formulas for calculating fetal weight have been produced in response to the reports. For measuring fetal weight, measurements other than those including soft tissue, including such those lean and adipose tissue or utilising 3D ultrasonography are acquired. For the purpose of sonographic pregnancy assessment, ultrasound examination of the thicknesses of subcutaneous tissue in the several body regions might evidence to become reliable indicator of the fetal weight.

Keywords: Pregnancy, postpartum hypoglycaemia, foetus, Intra-uterine, pregnancy ultrasound

INTRODUCTION

In obstetrics, ultrasound is utilised extremely frequently. The foetus may be imaged in great detail thanks to it, among other things. Every stage of pregnancy, though, is unique. It is possible for seeing gestational sac in the cavity of uterine at 4-5 weeks of gestation, diagnostic ultrasonography can already be used. The embryo's echo can be seen starting around week 5 or 6 of pregnancy.[1] The number of factors that must be evaluated and the level of difficulty of such ultrasound technique both rise as that the pregnancy progresses.[2] This method's information on the growing embryo allows for diagnosis, prediction, and treatment of some of the fetal diseases. The ease of the use and non-invasiveness of diagnostic ultrasound are its main benefits.[1,3] As of the most recent reports, pregnancy ultrasound scans were safe and have no impact on fetal weight, the risk of early labour, the state of the child at delivery, or perinatal death.[4] Additionally, sonography has several limits, particularly when it has been difficult to see the foetus because of bad technical circumstances, an anterior placenta, the mother's obesity, or the oligohydramnios[5]. By early abnormality diagnosis, ultrasonography scanning in the pregnancy primarily aims to reduce risk of the obstetric problems.[6] Which include fetal development disorders including IUGR (macrosomia & intrauterine growth restriction), which are much more prevalent in pregnancies complex and difficult by illnesses like obesity, diabetes, hypertension, fetal genetic anomalies, or nicotine addiction, among others.[7–9]

Abnormalities of fetal growth: There has been an increase in the maximum birth weight for the gestational age newborns during the past few years. Macrosomia, which could be defined as the fetal weight over 4500 grams regardless of the age of fetal or above 90% for the specific gestational age and demographic, is the medical term for this phenomenon.[10] The estimated fetal weight in pregnancies complicated by diabetes surpasses 4200g.[11] Macrosomia is 6-14.5 percent common in the general population and 25-42 percent in women with the diabetes.[12] Post-term labour, Maternal obesity, history of birth giving to multiparity, advanced maternal age, macrosomic children, hyperinsulinemia and the male fetuses, are risk factors for the macrosomia in addition to maternal diabetes.[13] Multiple issues are linked to macrosomia for both mother and fetus. For the fetuses & the newborns, these may include shoulder dystocia, the increased mortality, postpartum hypoglycaemia, infections, systemic defects, prolonged jaundice, calcium deficiency, perinatal trauma & respiratory issues, among the other conditions.[13,14] For the mothers, the macrosomia was linked to a greater risk of caesarean birth and postpartum haemorrhage, and also an greater/high risk of the perinatal trauma like the anal sphincter and pelvic diaphragm injury.[15] The aforementioned issues can be avoided if macrosomia is discovered early.

Intra-uterine limitation is another category of aberrant intra-uterine growth. This phrase is thought to apply to fetuses whose estimated body weight or measurement of their belly circumference falls below the 10th percentile[16] It is thought that placental insufficiency, or reduced circulation of fetoplacental unit, is indeed the likely cause of intra-uterine growth limitation.[16] While the causes of intra-uterine growth restriction could be divided into fetal, placental, maternal, and environmental variables, the etiopathogenesis of this condition is yet unknown.[12,17] mother's small stature, arterial hypertension, diabetes with vascular problems, low body mass, nicotine addiction, kidney disorders, obesity, autoimmune diseases, anaemia, and pregnancy-related cholestasis disorder are among the most prevalent risk factors Fetuses having low body weight due to genetics or constitution and those having pathological disorders such intra-uterine growth restriction are suspected of having a growth deficiency.[7,18,19] Given that low birth weight causes 69.6 percent of newborn deaths and 66.46% of intra-uterine deaths, it is a significant issue in the obstetrics. Estimation regularly of the fetal weight or the assessment of the circumference of fetal abdominal in the pregnancies with higher risk is a best diagnostic technique for this condition.[20]

Fetal weight estimation: At the moment, morphometric formulas are employed to calculate fetal weight. They use fundamental biometric measurements such head circumference, belly circumference, biparietal diameter and the length of femur.[17] The Shepard and Hadlock formulas are the most popular, though they have several drawbacks. For such detection of fetal macrosomia, the Hadlock formula has a sensitivity & specificity of 62 & 93 percent, respectively, while Shepard formula has a specificity and sensitivity of the 99 and 21 percent respectively. For such a reason, the investigators from all over the globe have searching for

additional characteristics of sonograph having a stronger predictive value that correlate with fetal weight. The fetal parameters that were investigated were the size of the liver, the kidneys, the cerebellum, the volume of the femur, the distance between the cheeks and the upper arm's soft tissue.[21]

Measurements of soft tissue: Scapular soft tissue and fetal abdominal measurements: According to recent scientific findings, assessing fetal weight can benefit from using new sonographic parameters including measurements of the soft tissue thickness. The fetus's body could be examined in a number of locations for the measures. For instance, thickness of subcutaneous tissue could be assessed in subscapular, abdominal, or the upper arm regions. Different measurements have varying degrees of connection with the other sonographic and anthropometric factors, including body mass and the gestational age. Fetal weight and the FASTT (fetal abdominal soft tissue thickness) in the 3rd trimester of the pregnancy were found to be strongly positively correlated with in study where the $r = 0.86$, $p < 0.001$. 300 participants between 32 & 42 weeks of the pregnancy were enrolled in trial. The subcutaneous tissue somewhere at anterior 3rd of the abdomen circumference here between the inner and the outer edge of the echogenic subcutaneous tissue was measured using ultrasound as part of study technique. Adipose tissue thickness varied from 3 mm to 14 mm, having the mean of 6.7±1.9 mm. The study examined 744 women who were physiologically pregnant in greater detail. They showed a substantial correlation between fetal age and adipose tissue thicknesses measured during the 2nd and 3rd trimesters of the pregnancy at the fetus's belly ($r^2 = 0.792$), ($p < 0.0001$) and the subscapular area ($r^2 = 0.302$), ($p < 0.0001$). The procedure for measuring abdominal fat tissue was analogous to one previously mentioned. After completing the entire scapula visualisation, the calliper was positioned perpendicular to a low end of scale of scapula between the skin and the subcutaneous tissue boundary for measurement of the thickness of the FSSTT (fetal subscapular soft tissue). Even more instructive was a study by the study, which compared the 3 groups of the patients: those with the pregnancy physiologically, those whose pregnancies were complicated by the class one diabetes treated by the diet, and those with complicated pregnancies by the class 2 diabetes treated by the diet and the insulin.[8,10] They found that weight was significantly higher for complicated diabetes-related pregnancies treated with diet alone compared to pregnancies of the patients having normal glucose tolerance tests and the patients with the diabetes treated by the insulin and diet. Between the 24 & 35 weeks of the diabetes, there are significant variations between the thickness of subcutaneous tissue values in between the patients with the diabetes and the patients having pregnancy physiologically, however there were none between 36 & 40 weeks of gestation. The researchers emphasise that measuring thesubcutaneous tissue could be another helpful metric for evaluating how well individuals with diabetes are being managed throughout pregnancy in the study's conclusion.[12]

Measurement of thickness of fetal humeral soft tissue: It is also possible to assess the FHSTT, or fetal humeral soft tissue thickness. Al-Hilli showed in her research that the Hadlock formula is much more specific but also less sensitive than humeral soft tissue thickness. In comparison to the conventional formula, it has higher predictive value negative. To measure soft tissues, close below humerus, the FHSTT procedure entailed seeing humerus in longitudinal section, rotating transducer 90 degrees, and moving it towards humeral head.[22]

Measurement of thickness of fetal thigh soft tissue: Fetal thigh Soft Tissue Thickness (FTSTT) is other novel sonographic measure. There has only been one report on this metric to yet, but the findings are encouraging. It has a substantial correlation with fetal belly circumference and birth weight, claims the study. This judgement was made in light of a study that was carried out in three stages with a total of 290 patients. The measurement procedure entailed visualising the femur in the longitudinal section, stopping picture, and the measuring of the distance between both outer surface of the thigh and outer surface of the femur in its middle portion perpendicular to bone.[3] In initial phase of investigation, there is a linear link between the birth weight and the dimensions of circumference of head, the diameter of biparietal, the belly circumference, and the length of femur, and the FTSTT also confirmed. In following stage, a novel, modified formula for the estimation of the fetal weight utilizing FTSTT and FL data was determined. In final step, the findings of three formulae of Hadlock and Shepard and the new Scioscia formula are compared, two of which are well-known. The authors emphasise that both the Hadlock & Scioscia formulas produce satisfactory results ($p > 0.05$), while drawing attention to new formula's improved accuracy ($r = 0.79$). Additionally, being researched is utilize for the fetal soft tissue measures and for diagnosis of the macrosomia. FTSTT's diagnostic value for fetal macrosomia was established by the study, which had sensitivity and specificity of 91% and 94%, respectively. They also underlined that other sonographic parameters may not be as useful for the estimation of fetal weight as FTSTT, which exhibits a positive correlation with gestational age. This is supported by research, which found that macrosomia pregnancies had significantly higher values for fetal belly circumference, length of femur, and thickness of the thigh subcutaneous tissue. The study also looked at a new indicator, which is the correlation in between length of the femur as well as the thickness of a subcutaneous tissue inside the fetal thigh; however, for macrosomic pregnancies, no significant changes were found where $p = 0.067$. Correlation of FTSTT as just the predictor of high birth weight is not validated in research, though researcher caution there is a significant time lag in between several ultrasound scans and the delivery, that may have compromised by the validity of the study. In a study, the issue of the sonographic measures of the FTSTT in the low-risk and the pregnancies of the high risk was brought up. They discovered that birth weight and length increase with the increasing FTSTT. While there was no association between FTSTT and the increase in body mass throughout pregnancy or the pregnant women's BMI, there was significant correlation statistically in between the body mass and the FTSTT of the women before the delivery and the pregnancy.[23] Between 48 and 38 weeks of the pregnancy, neonates with the higher birth weights had higher FTSTT values; even so, no such relationship was seen for the pregnancies in between 41 and 37 weeks.

Measurements of use of the fetal soft tissue: Numerous research has been conducted that suggest new formulas for calculating fetal weight in light of the aforementioned results. Currently, the best indicator of fetal weight is fetal abdominal circumference. Nevertheless, there is a significant chance of mistake, especially when it is impossible to guarantee ideal measuring conditions throughout the scan. Even for a skilled examiner, getting a high-quality image of ultrasound is challenging. Lower-quality graphics' measurements have a higher rate of mistake. Because of this, a study created formula which is new for calculating the weight of fetal. They came up with a formula is based on mathematical analysis that makes use of the FL and the FTSTT. This formula does have the advantages of being simple to inspect and allowing measures to be taken even though the fetus's head is low in pelvis and out of reach of examiner. With an absolute error in mean rate is below the 15% in more than 90 percent of the cases, the Scioscia and Hadlock formulas were deemed to be equally as effective at estimating the actual fetal weight.[15] These findings are supported by a study that first confirmed the applicability of the Scioscia formula before modifying it to compare the outcomes of both the formulae. Both formulas showed a substantial link with both the neonate's birth weight, according with authors, even though the original Scioscia formula had a stronger correlation where $r^2 = 0.609$, and $p < 0.001$ than that of the formula which is modified where $r^2 = 0.957$, and $p < 0.001$. When weight was calculated utilizing the Scioscia formula, which is only considers the FTSTT and the FL, they

discovered a slight association. They also discovered that applying this approach causes larger fetuses to be overestimated and smaller ones to be underestimated. The authors hypothesise that the disparities were caused by the small number of macrosomic fetuses they included in the study.[15,24] Since the focus of the research was to examine the application of the formula in a such circumstances, ultrasound scans were carried out in th admissions department by resident doctors with various levels of competence. A study also worked on creation of the new formulas for the estimation of the fetal weight. A study was using a variety of pairings of FTSTT and commonly used sonographic measures. The formula with maximum predictive power where r = 0.77, which incorporated AC, FL, and HC with FTSTT.

Aside from the soft tissue, other, more complex assessments including adipose and the lean tissue are also made. Research presents the findings of these measurements. The measurement process entailed seeing the transverse section of the fetal bones while rotating the transducer by the 90 degrees to acquire a longitudinal section of long bones, therefore in this case the humerus and femur. The difference between both the thickness of lean tissue, such as bones and muscles, as well as the total thickness of the subcutaneous tissue is known as the adipose tissue thickness. Both of these metrics have a distinctive growth profile, according to the authors. Such measurements might be sensitive more and precise indicator of the abnormalities of fetal growth because of the rapid fetal growth in the late pregnancy. [24] Another study employed them as the more accurate indicator of fetal body form.

Only a small number of articles address FTSTT in the pregnancies with IUGR, in contrast to numerous investigations on novel sonographic parameters in the pregnancies physiologically and those which are complicated by the macrosomia. Only 39 of the 232 babies examined by ultrasound in the study were determined to be very small for the gestational age.[25] With a sensitivity of 74% and specificity of 94%, the assessment of sonograph of the soft tissues of thigh in this group of fetuses demonstrated a significant precision (74percent) in connection to the low birth weight. Additionally for measuring the fetal abdomen and the subscapular soft tissues, A study evaluated the lean muscle and adipose tissue of femur and humerus in their investigation. In the fetuses with the restriction of intra-uterine growth, abdominal, subscapular, and humeral subcutaneous values were significantly lower, according to the study's authors. The study has one of few to include patients having the arterial hypertension. A study that looked at 2 populations of the pregnant women who are living at the altitudes that were 1600 metres apart in absolute terms may have made a very interesting observation in this regard. The scientists noted that the fetuses of women who resided in the higher location had lower values for the thickness of the subcutaneous tissues in the abdomen, thighs, and upper arms. There were no variations in the two populations' muscle tissue values, though. A study that looked at 240 patients' abdomen, thigh, and parameters of calf subcutaneous tissue offers a different point of view. 38 fetuses had high body weights, and 13 fetuses had intrauterine growth retardation. The researchers came to the conclusion that neither the group could use sonographic parameters as trustworthy predictions[26]

Use of 3D ultrasound: Researchers are looking for approaches to determine fetal weight using 3D ultrasound in addition to 2D sonography. the researchers that developed a method for estimating fetal weight based on study of the 3D measurements of thigh in one of the earliest investigations on this topic. Their formula was more accurate than earlier techniques that relied on 2D measurements. The authors' formula has an absolute error rate of 5.9 percent Similar to this, a study used measurements 3-dimentionally of upper arm, which they had utilized for more accurate estimation of the fetal weight than they could have using the conventional techniques. Both investigations were preliminary findings, and the only factor in formula employed was the 3D ultrasound readings. In contrast, a study created formula based on the 3D measures of fetus's abdomen, thighs, and upper arms in addition to a typical the BPD 2D measurement.[2,3] Compared to conventional formula based on 2D measurements, new formula exhibited significantly lower rate of mean error. Combining the 3D measurements with the other fetal biometric data including FL, HC, and BPD allowed for even more accurate assessment of the body mass in the small fetuses (below the 1600 gram) (30). The utilization of the 3D measures for estimation of the fetal weight, according to the scientists, is more accurate but also requires more time because it takes an average of 10-15 minutes to assess each leg. In their work, a researcher sought to improve the usefulness of 3D ultrasound by reducing the measuring time to 10 seconds utilising a for-profit programme.[2,3] The examination made use of a hybrid transducer, which made it possible to derive the FL, BPD, and AC from volume data. The researcher came to the conclusion that adding upper arm or thigh volume measurements to AC and BPD measurements increases precision. The average difference between the measured and actual fetal weights was 6.6 percent. It was 8.5 percent in the case of common Hadlock formula.

CONCLUSION

In obstetrics, the accurate estimation of fetal weight is crucial since it affects both the progress and conclusion of labour and delivery. The pregnant mother as well as the foetus may experience numerous, frequently deadly issues as a result of incorrect fetal weight assessment. The present Hadlock formula for the estimation of the fetal weight have a 20% rate of error, which might vary depending on examiner's expertise, the equipment utilised, the circumstances of the examination, and the stage if the pregnancy or the labour. The new parameters that could be utilized for forecasting fetal weight have been reported as a result. Finding a diagnostic tool that is really quick to be utilize, reproducible by the several examiners, and has a low error rate is the goal of researchers worldwide. Measurements of the thickness of fetal soft tissue in the 2 and the 3 dimensions might show such a parameter. The present publications on subject are inconsistent, and the studies were frequently carried out on tiny patient populations, which severely restricts the potential future use of these data. For the purpose of sonographic pregnancy assessment, the subcutaneous tissue thickness measurements using ultrasound in several body regions might prove to be highly reliable predictor of the fetal weight.

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