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The Accuracy of Ultrasonic Fetal Weight Estimation In Comparims With Actual Birth Weight At Term

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ABSTRACT

Background and objective: To assess the validity of ultrasound estimation of fetal weight at term by Hadlock formula.

Patients and Methods: The data was obtained from 100 full term pregnant women, the high risk women were excluded (those who had hypertension, diabetes mellitus, oligohydramnios and premature labor). The study was done from June 2015 to December 2016 in AL-Salam General hospital and AL-Batool Hospital, Mosul, Iraq. Fetal weight is measured ultrasonographically using four parameters: biparietal diameter, head circumference, abdominal circumference and femur length using Hadlock formula, one day before delivery, and then the actual birth weight was estimated immediately after delivery whether by normal vaginal delivery or planned Cesarean section. The newborn weight was estimated in labor ward by the same metric scale.

Results: The mean fetal weight by Hadlock formula was lower than the mean of actual birth weight by 70 + 41 gram , the mean gestational age of sample size was (37.64) weeks, the mean maternal age was (30.96) years, 60% of cases were delivered by normal vaginal delivery and 40% were delivered by caesarian section. According to this study the sensitivity was 83.5 %, specificity was 95.5% and accuracy rate was 87%.

Conclusion: Fetal weight estimation by ultrasound using Hadlock formula within 24 hour before labor considered clinically accurate.

Key Words: Fetal weight /Biparietal Diameter /Head Circumference /Abdomen Circumference/Femur Length /Intrauterine Growth Restriction (IUGR)

INTRODUCTION

Obstetric Ultrasound

The advantages of diagnostic ultrasound primarily include non-invasiveness and ease of the procedure[(1)].According to the latest reports, ultrasound scans performed during pregnancy are safe and do not affect fetal weight, premature labor risk, the child's condition at birth or perinatal mortality[(2)].

The obstetric US examination consists of a survey of the uterus and maternal pelvic organs, measurements of the fetus to date the pregnancy and assess fetal growth, and a survey of fetal anatomy. Standards for the performance of obstetric US examinations have been published by the American Institute of Ultrasound in Medicine and endorsed by the American College of Radiology and the American College of Obstetricians and Gynecologists[(3)].

Currently, morphometric formulae are used for estimating fetal weight. They utilize basic biometric parameters such as biparietal diameter, head circumference, abdominal circumference and femur length[(4)]. Assessment of fetal anatomy includes the cerebellum, cisterna magna, lateral cerebral ventricles, choroid plexus, midline falx, cavum septum pellucidum, a four-chamber view of the heart and ventricular outflow tracts, and images of the entire spine, stomach, kidneys, bladder, umbilical cord insertion site, umbilical cord vessel number, arms and legs [(5)].

Fetal Measurements and Growth

Dating the pregnancy and determining the appropriateness of fetal growth are essential to obstetric care. Clinical dating is based on history of the mother's lastmenstrual period (LMP) and bimanual assessment of uterine size. Sonographic dating is based on measurements of the gestational sac and the embryo or fetus. Serial measurements of fetal parameters are used to document growth. By convention, pregnancies are dated from the first day of the LMP [(6)].

The terms gestational age (GA), which is the clinical standard, and menstrual age are usually considered to be synonymous terms and are based on the average 28-day menstrual cycle. Conception is assumed to occur 14 days following the LMP. Term is 40 weeks, with an acceptable range of 37 to 42 weeks [(6)].

Biparietal diameter (BPD)

BPD measured on an axial image of the fetal head at the level of the third ventricle and thalamus (Fig.1.1). By convention, the measurement is made from the outer table of the near cranium to the inner table of the far cranium. The measurement is affected by head shape and provides an inaccurate estimate of GA if significant dolichocephaly (elongated skull) or brachycephaly (round skull) is present).

Head circumference (HC)

It is the outer perimeter of the fetal cranium, measured in the same plane as the BPD (Fig. 1.). The HC measurement is relatively independent of head shape).

Abdominal circumference (AC)

It is the outer perimeter of the fetal abdomen, measured on an axial plane image at the level of the intrahepatic portion of the umbilical vein (Fig.2)[(7)].

Femur length (FL)

It is the measurement of the ossified portion of the femoral diaphysis (Fig.3). The entire femur must be imaged, and the femoral shaft must be centered in the beam so that it casts an acoustic shadow[(7)].

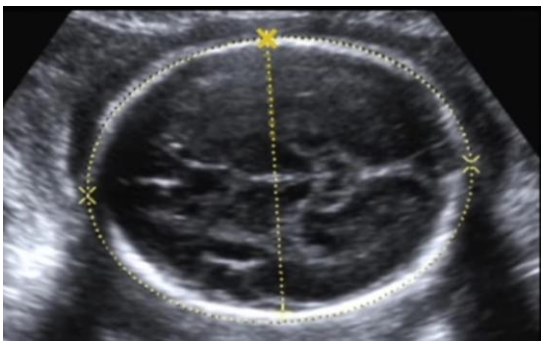

Figure 1: Transthalamic (Biparietal Diameter/Head Circumference) Plane.

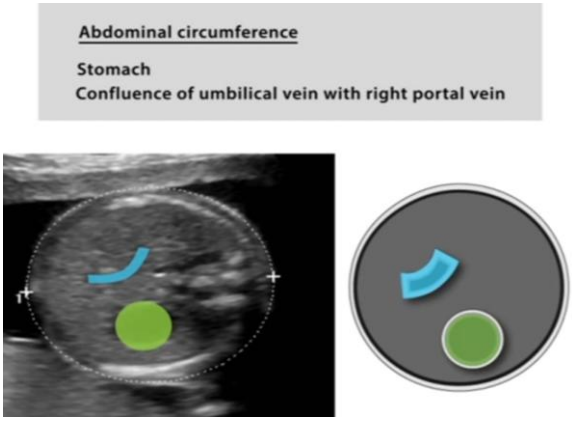

Figure 2: Abdominal Circumference,

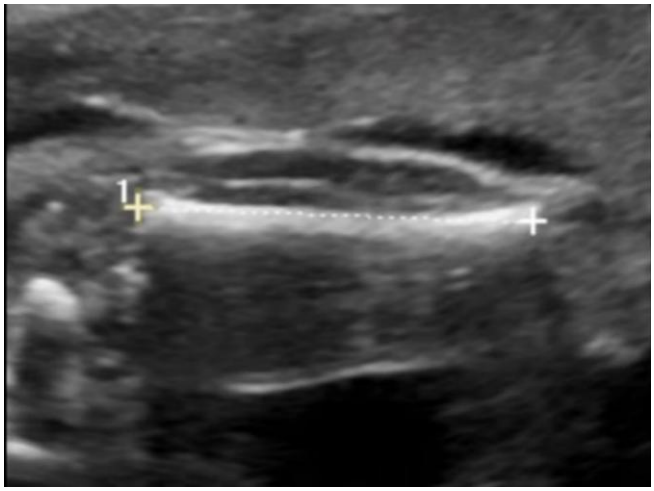

Figure 3: Femur Length.

Gestational Age

Estimation of GA is most accurate in early pregnancy and become progressively less accurate as the pregnancy advances. The composite age, calculated by averaging the GA estimates of multiple parameters, is more accurate than any single parameter because fetal anomalies may make individual parameters inaccurate for estimation of GA. Body parts with structural anomalies should be excluded from the composite GA estimation[(8).]

The composite of BPD, HC, AC, and FL measurements predicts GA, which is accurate to about 1.2 weeks at 12 to 18 weeks, but the composite age is accurate to only about 3.1 weeks at 36 to 42 weeks. GA is assigned at the time of the first US and is not changed thereafter [(8).]

All subsequent US examinations are compared with the first examination to assess fetal growth.

Normal Fetal Head

The Trans thalamic plane is used to measure the BPD and HC (Fig.1.). Abnormalities of head shape, microcephaly, macrocephaly, and major structural abnormalities are evident in this plane. The third ventricle varies in appearance from a single echogenic line to a slit like structure narrower than 3.5 mm.

The trans ventricular plane is an axial plane at the level of the ventricular atria the dominant landmark is the echogenic choroid plexus, which normally fills the atrium nearly completely. Measurements of atrial diameter made perpendicular to the walls do not normally exceed 10 mm).

The Trans cerebellar plane is an axial scan at approximately 10° to 15oof inclination from the canthomeatal line. The anatomic landmarks include the inferior portion of the third ventricle and the cerebellar hemispheres, which are outlined by fluid in the cisterna magna .The normal cisterna magna measures 2 to 11 mm in width. A small cisterna magna (<2 mm) suggests a Chiari II malformation but may also be seen with massive ventriculomegaly. A large cisterna magna (>11 mm) may be a normal variant (mega cisterna magna) or indicate Dandy-Walker malformation, arachnoid cyst, or cerebellar hypoplasia. When these three planes are anatomically normal, the risk of CNS anomaly is minute (0.005%)[(8).]

Normal Fetal Abdomen

The abdomen of the fetus is significantly different from the abdomen of the older child or adult. The abdomen of the fetus is large relative to its body length compared with the adult. The liver is large, and the left lobe is larger than the right lobe [(9).]

The umbilical vein is an important US landmark. Half the blood it carries goes directly to the inferior vena cava via the ductus venosus. The remainder perfuses the liver via the left portal vein.

The adrenal glands are up to 20 times larger in relative size because of the presence of the fetal zone.

The pelvis is relatively small, and the pelvic organs extend into the lower abdomen.

Swallowing begins at 11 to 12 weeks GA. The fetal stomach should be filled with swallowed fluid by 18 weeks GA. The small bowel is moderately echogenic, centrally located, and blends with the liver. By the third trimester, peristalsis in small bowel loops can be observed. The visualized small bowel loops are normally less than 6 mm in diameter and less than 15 mm in length. The colon is visualized after 20 weeks as a tubular structure around the periphery of the abdomen. The colon progressively fills with meconium but does not exceed 23 mm in diameter[10].

Normal fetal kidneys are seen as paired, slightly hypoechoic structures adjacent to the spine. The renal sinus appears as an echogenic stripe. Fetal lobulation causes an undulating contour of the kidneys. The length of normal fetal kidneys in millimeters is approximately equal to GA in weeks. The bladder should be observed to fill and empty. Because amniotic fluid is predominantly urine, a normal amniotic fluid volume implies at least one functioning kidney[11].

Measurement of fetal abdominal diameter and circumference were first used to estimate fetal weight by Campbell and Wilkin in 1975. since then abdominal circumference (AC) has become the main fetal parameters used to estimate fetal weight before birth. It is widely used to detect and monitor fetal intrauterine growth retardation (IUGR) or fetal macrosomia in diabetic pregnancies [12].

Intrauterine Growth Restriction (IUGR)

Fetuses with impaired intrauterine growth have an increased risk of intrauterine demise and a perinatal mortality rate four to eight times greater than normal-sized fetuses Half the survivors have significant morbidity, including intrapartum fetal distress, hypoglycemia, hypocalcaemia, meconium aspiration pneumonia, impaired immune function, retarded neurologic development, and learning disabilities [13] .

A fetus or newborn is considered small for gestational age (SGA) if its weight is below the 10th percentile for GA. This definition will encompass normal infants who are constitutionally small as well as infants with IUGR who are pathologically small [14] .

Fetuses with intrinsic insults have fixed defects and will not benefit from early delivery. The pattern of growth impairment occurs early in the second trimester and tends to be symmetric, in that the head, abdomen and femur are all proportionally small. Fetuses exposed to an extrinsically impaired growth environment will usually benefit from therapy that commonly includes early delivery.

Growth impairment occurs in the late second and third trimesters and tends to be asymmetric, in that the fetal abdomen is disproportionately small relative to the head and femur. The AC is small because of diminished glycogen stores in the fetal liver and decreased subcutaneous fat [7] .

Causes of Intrauterine Growth Restriction
Intrinsic causes
Chromosome abnormalities (trisomy, triploidy)
Intrauterine infection (rubella, CMV, toxoplasmosis)
Structural abnormalities (congenital heart disease)
Teratogen exposure

Extrinsic causes
Primary placental insufficiency
Maternal hypertension
Chronic maternal diseases (anemia, renal failure)
Maternal malnutrition
Maternal smoking, alcohol, and drug abuse
Multiple gestation

Fetal Macrosomia

Defined as estimated fetal weight above the 90th percentile for GA table (2) or a fetal weight above 4,000 g. Risk factors include maternal diabetes, maternal obesity, previous history of macrosomic infant, and excessive weight gain during pregnancy. Complications of macrosomia are manifest at delivery and include shoulder dystocia, traumatic delivery, fractures, brachial plexus injury, perinatal asphyxia, neonatal hypoglycemia, and meconium aspiration. As well as maternal risks that includes birth canal injuries, pelvic floor damage, and postpartum hemorrhage[17].

So determining fetal weight will provide the obstetrician important information about the way how to deliver the baby wither normal vaginal or through cesarean section according to his weight or even prolongation of pregnancy in case of small for gestational age[18].

A prospective study was carried out over a period of 6 months from June 2011 to December 2011.One hundred pregnant women were randomly selected from a group of antenatal people at the gestational age between 37-42 weeks of gestation. The women were recruited from delivery unit at Maternity teaching hospital, in Erbil city North of Iraq, Kurdistan Region, all ultrasonic examination done by the researcher and only single measurement was made for each variable.

The estimated gestational age and expected date of delivery were established from the last menstrual period of the pregnant women. All the cases are scanned within 24 hours before delivery and those who delivered after that has been excluded from the analysis.

Philips machine, probe C5-2 (curvilinear) with A 3.5 MHz (Megahertz) transducer is used to measure birth weight by Hadlock formula depending on four parameters: (BPD), (HC), (FL) and (AC).

BPD was measured on an axial image of the fetal head at the level of the third ventricle and thalamus. the measurement is made from the outer table of the near cranium to the inner table of the far cranium. Figure (1.)

HC is the outer perimeter of the fetal cranium, and was measured in the same plane as the BPD. Fig (1) AC is the outer perimeter of the fetal abdomen, measured on an axial plane image at the level of the intrahepatic portion of the umbilical vein. the plane is perpendicular to the fetal spine which intersects only a small portion of the umbilical vein, the stomach is also seen at this plane figure(2)

FL was measured along the ossified portion of the femoral diaphysis, the entire femur was imaged, and the femoral shaft was centered in the beam so that it casts an acoustic shadow the portion of the femur measured is from the greater trochanter to the femoral condyles figure(3)

The U/S machine was computerized where the fetal weight was recorded after estimation of the four parameters, these measurements were taken with the aid of electronic calipers on the ultrasound machine. The estimated fetal weights were estimated by the Hadlock formula [(19)].

EFW (BPD, HC, AC, FL) Via Hadlock:

The formula for the estimated fetal weight (gram) via Hadlock, using biparietal diameter (range: 3.1 to 10.0 cm), head circumference (range: 10.0 to 40 cm), abdominal circumference (range: 15.0 to 40.0 cm), and femur length (range: 1.0 to 8.0 cm) is: =10(15115 + 0.0436 x AC +0.1517 X FL - 0.00321 x FL +0.0006923 x BPD X HC)[(19)].

Actual birth weights were obtained after the babies had been born either by normal vaginal delivery at labor room or by ceasarean section at operative room where same metric scale (electronic baby scale called TANITA model 1583) has been used for both cases. Informal verbal consent was taken from each pregnant mother.

Statistical application:

Statistical Package for Social Sciences (SPSS) version 13 used for data entry and analysis.
Student T-test "unpaired" was used
T=1.794 calculated
T=1.642 tabulated
P. value: less than 0.01 at 95% confidence interval.
Statistically the U/S is highly significant in estimating fetal weight within 24 hours before labour.

RESULT

A total of 150 full term pregnant women were interviewed with the protocol of study over a 6 months period. One hundred only pregnant women were complete the study protocol. The rest were excluded because of non-delivery within twenty four hours and missing data.

Age of the study population:

The age ranges of the women studied were from 15 to 35 years with a mean of (30.96 years).

The age distribution of the study population showed the highest percentage (48%) was of age group (26-30) years and the lowest percentage (12%) was of (31 - 35) years as shown in (table 1).

Table 1: Age Distribution of study population

Age (years)	No. of cases	Percentage
15-20	18	18%
21-25	22	22%
26-30	48	48%
31-35	12	12%

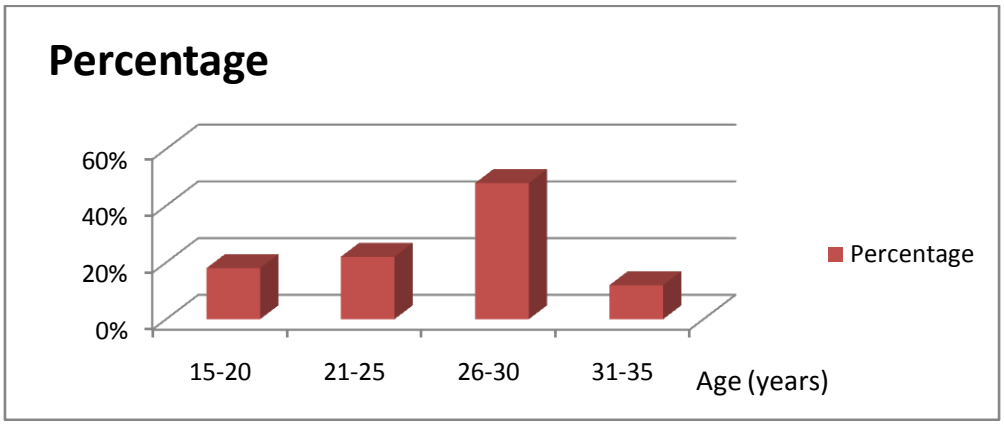

Fig 4: Age Distribution of study population

Gestational age of study population:

The range of gestational age at time of ultrasonic fetal weight estimation was (37-42 weeks) mean (37-64 weeks), where 62% of study populations were at 37 weeks of gestation and about 18% for each of 38 and 39 weeks, 2% for 42 weeks and 0% for both 40 and 41 weeks.

Table 2: Distribution of gestational age

No. of weeks of pregnancy	Percentage %
37	62
38	18
39	18
40	0
41	0
42	2

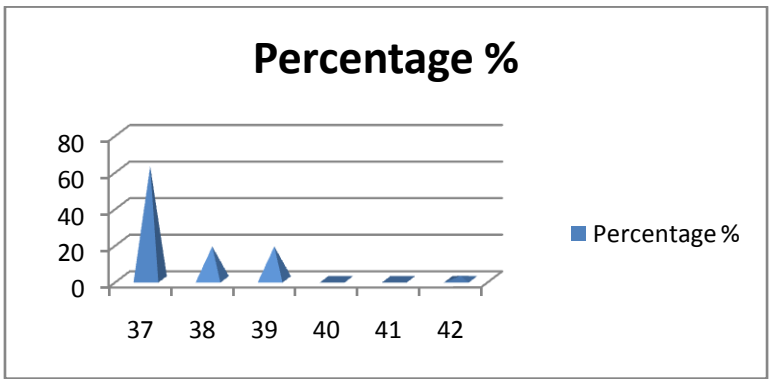

Fig 5 Distribution of gestational age (weeks)

Mode of delivery: 60% of pregnant women by normal vaginal delivery, while 40% of them delivered caesarian section (CS).

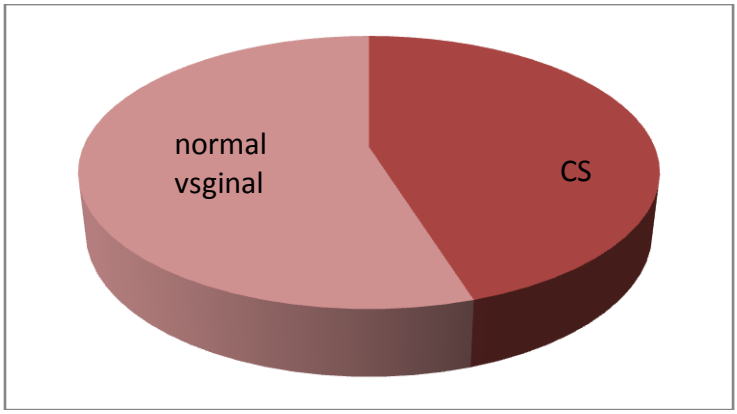

Fig 6: Mode of delivery

Table 3: The demographic data of studying population (100cases)

Data	Range	Mean
Age (years)	15-35	30.96
Gestational (weeks)	37-42	37.64

The estimated fetal weight and actual birth weight
The range of estimated fetal weight was from 2.035 3.603 gram, Mean (gram) + SD = 3.019 + 0.446 (gram)
The range of actual birth weight was from 2.200 -3.700 gram, Mean (gram) + SD = 3.089+ 0.528(gram)
The difference between mean actual birth weight and mean estimated feweight was 0.070 gram +0.041 as shown in (table 4).

Table 4: correlation between the mean of actual birth weight ar the mean of estimated fetal weight by ultrasound:

Mean actual birth weight(gm) + SD	Mean estimated fetal weight (gm) + SD	Mean weight difference(gm)+SD
3.089+ 0.528	3.019+0.446	0.070+ 0.041

The validity of the study including:

Sensitivity (83.5%), specificity (95.5 %) and accuracy (87%). Accurate estimation of fetal weight is of great importance in detecting small for gestational age and large for date fetuses and determining the way of management of labour to optimize safe motherhood[20] .

In this study, there were under estimation of fetal weights by 70 gram. We use the Hadlock formula in the estimation of fetal weight depending on four parameters: (BPD), (HC), (FL), and (AC). We include in our study only low risk (no hypertension, no diabetes mellitus), full term pregnant women (between 37 weeks to 42 weeks of gestation).

As well as we use the least time interval between ultrasonic scanning and fetal delivery (up to 24 hour) This is due to the fact that fetuses gain weight rapidly during the last trimester of pregnancy. This therefore may cause estimation of fetal weight to be less accurate the longer the scan - delivery interval.

In addition to that abdominal circumference measurement had been found to be less accurate in cases of oligohydramnios because the fetal skin edge may be difficult to identify when liquor volume is diminished and therefore those cases with oligohydramnios has been excluded from the study.

All these measures should give best result, In spite of that there were under estimation of fetal weights. In comparism with the study done in same locality in Iraq / in Maternity Teaching Hospital in Erbil city on two hundred full term pregnant women between (38-42 weeks) by Alalaf and Sedik([23]) using Hadlock formula and depending on two parameters only: abdominal circumference (AC) and femur length (FL), in the last week of pregnancy showed slightly best result were the estimated fetal weight was only approximately 50 gram less than actual birth weight. [23] and the reason behind this slight difference may related to the larger number of the study population which has been used.

Comparing to study done in United Kingdom in Department of Obstetrics and Gynecology, Ninewells Hospital and Medical School, Dunde; the Department of Obstetrics and Gynecology, Stobhill Hospital, Glasgow; and the Division of Reproduction and Child Health, University of Birmingham, Edgbaston, Birmingham, by Chien, Patrick F. W. MD; Owen, Philip MD; Khan, Khalid S. Using four methods for measuring fetal weight, the Aoki, Campbell and Wilkin, Shepard et al, and Hadlock et al formulas. These formulas utilize one or more of those fetal biometric measurements to calculate the fetal weight (AC, BPD, HC and FL). The smallest mean difference was obtained with the Shepard and Aoki formulas (51.4 g and 60.5 g, respectively); whereas the Campbell and Hadlock formulas produced larger mean differences (141.8 g and 190.7 g, respectively). So our result in comparism with the result of Hadlock formula was better were the estimated fetal weight was lower than actual birth weight by 190 gram while our result was only 70 gram the reason behind that I think because of small number of population which has been used by the above mentioned study only 50 pregnant women [(24).]

Other study done in Thailand, Department of Obstetrics and Gynecology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok by Japarath Prechapanich MD, Wiboolphan Thitadilok MD Shows the estimated fetal weight by two methods ultrasonographically (using standard Sonographic measurement of BPD, HC, AC and FL by Shepard method) and clinically (by fundal height palpation) were both showed lower result than actual birth weight by approximately (264.7) and (265.0) grams, respectively. Which in comparism with our study it is less accurate in spite of the large number of study population which has been used in their study about 297 cases, but I think the reason behind this difference is the use of Shepard method which seems to be less accurate than Hadlock formulas[(25)].

A retrospective study for 7-year period from July 1998 to June 2005 on term infants (237 weeks gestation) who had undergone an ultrasound estimation of fetal weight (calculated using a locally modified Woo formula) at the Perinatal Ultrasound Unit (Wellington city New Zealand) and who delivered <7 days after the measurement, to assess the reliability of ultrasound estimation of fetal weight undertaken antenatally, there result was the ultrasonic estimation of fetal weight significantly correlated with actual birth weight for all infants ($R=0.879$, $p< 0.001$) the calculation of weight based on ultrasound measurements tended to overestimate the weight of low birth weight infants while underestimating the birth weight of large babies [(26)] .

A study done in Germany, in department of prenatal diagnosis and therapy, center for Obstetric and Gynecology and Institute for Medical Statistics, University Hospital Bonn, by R. L. SCHILD, R. FIMMERS and M. HANSMANN. Were using three dimensional ultrasound to assess fetal weight depending on measurement of Volume of the upper arm, the thigh and the abdomen were these three parameters employed to yield the best-fit formula for prediction of fetal weight at birth, the new three dimension formula proved to be superior to established two dimension equations with lowest mean error (25.8 + 194.4 gram). three dimension sonography allows superior fetal weight estimation by including soft tissue volume [(27)] .

In our locality we cannot use three dimension ultrasonographic fetal weight estimation because of limited facilities in public hospitals. It is stated by Australian Society for Ultrasound in Medicine that "no formula for estimating fetal weight has achieved an accuracy which enables us to recommend its use[(28)]. Despite the large number of formulae available"[(29)].

The accuracy of ultrasonic estimations of fetal weight is limited by the fact that the mature fetus is an irregular, three dimensional structure of varying density, the weight of which cannot be calculated with certainty from biometric measurements [(30).]

Ultrasound estimation of fetal weight performed at Maternity teaching hospital within 24 hour of delivery in term singleton pregnancies was at least similar and sometimes better than that reported in other studies.

The conclusion from this study is that different formulae have different degrees of accuracies in different environment. It should however be noted that scan delivery interval is one of the modifying factors in accurate prediction of fetal weight[(31)].

Fetal weight estimation at time of labour to assist in deciding the mode of delivery by Hadlock formula using four parameters (BPD, HC, FL and AC) seems to be very good method in our locality.

I advice future researcher to use larger sample and use three dimensional sonography and compare their result with other methods.

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